ASSESSMENT OF RISK FACTORS FOR EXCESS WEIGHT GAIN AND DEVELOPMENT OF OBESITY IN PRESCHOOL CHILDREN IN HO CHI MINH CITY, VIETNAM

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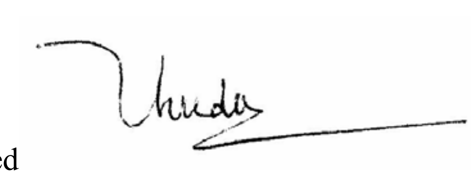
DECLARATION

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other university or institution

Signed 

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Huynh Thi Thu Dieu, Michael J. Dibley, David Sibbritt, Tran Thi Minh Hanh. Prevalence of overweight and obesity in preschool children and associated socio-demographic factors in Ho Chi Minh City, Vietnam. International Journal of Pediatric Obesity. 2007; 2: 40-50

This paper is an extract from Chapter 4 of the thesis.

Huynh Thi Thu Dieu, Michael J. Dibley, David W. Sibbritt, Tran Thi Minh Hanh. Trends in overweight and obesity in pre-school children in urban areas of Ho Chi Minh City, Vietnam, from 2002 to 2005. Public Health Nutrition. Accepted 2 May 2008.

This paper is an extract from Chapter 5 of the thesis.

Thesis Communications

Dieu Thi Thu Huynh, Michael J. Dibley. Prevalence, trend and risk factors for preschool children overweight and obesity in Ho Chi Minh City, Vietnam. Oral presentation at the School of Public Health seminar, the University of Sydney, 23, July 2007

This presentation is extracted from Chapters 5 and 8 of the thesis.

Abbreviations

The following abbreviations are used in this thesis:

HCMC:	Ho Chi Minh City
BMI:	Body mass index
WHO:	World Health Organisation
IOTF:	International Obesity Task Force
CDC:	Center for Prevention and Disease Control in USA
SES:	Socio-economic status
PR:	Prevalence ratio
RR:	Relative risk
95% CI:	95% confidence interval
FFQ:	Food frequency questionnaire
PPS:	Proportionate to the Population Size
UNICEF:	United Nation Children's Fund
DEXA:	Dual energy X-ray absorptiometry

Synopsis

Introduction: Surveillance data and other studies have indicated that the prevalence of overweight and obesity in preschool children in Ho Chi Minh City (HCMC) is increasing, particularly in urban areas. No studies have examined the speed at which this public health problem is emerging in child populations in urban Vietnam. Knowledge of the risk factors for preschool-aged child obesity is limited since earlier studies have been cross-sectional in design and potential risk factors at different levels have not been fully investigated.

Objectives: This study aimed to assess the prevalence and trends in overweight and obesity, and to identify the risk factors associated with longitudinal changes in adiposity over a one year period in preschool children in urban areas of HCMC. In addition, a sub-study aimed to validate a proxy-questionnaire for use in measuring physical activity of preschool children.

Method: Based on the available data from a cross-sectional study conducted with preschool children in HCMC in 2002, a restricted sample of 492 children aged four to five years from urban areas of HCMC was used for examining the trends in overweight and obesity in this child population, over the period from 2002 to 2005. The original study using the multi-stage cluster sampling was performed in preschool children aged one to six years in both urban and sub-urban areas of HCMC. A total of 1780 children aged one to six years participated in this study. Anthropometry of the subjects was measured using standard methods. Socio-demographic information was collected using a self-administered questionnaire.

The one year follow-up study, using multi-stage cluster sampling, was conducted from 2005 to 2006 with children aged four to five years in preschools in urban areas of HCMC. At baseline, 670 children participated in the study and of these, 526 children completed two follow-up measurements at 6 month intervals. Information on neighbourhood, preschool and home environments, socio-economic status, the child's and parental characteristics were collected using pre-coded, structured, interviewer-administered questionnaires. Dietary intake and physical activity were measured in the home and preschool settings using modified, validated questionnaires. Anthropometry including weight, height, skinfold thickness at triceps, subscapular and suprailiac sites were measured using standard methods.

The trends in overweight and obesity were examined based on data from the 2002 study and the baseline study of the cohort study. Data were collected in 2002 and made available for these secondary analyses.

The validation study of the proxy-questionnaire to measure physical activity of children aged four to five years was conducted from July, 2005 to November, 2005, using accelerometers as the criterion method. A subset of 83 children from the entire cohort study participated in this study. Physical activity data over the three months, reported by the teacher and the parents, were compared with data collected from the accelerometers for seven consecutive days.

Main outcomes: Body mass index (BMI) was calculated from measured weight and height. Overweight and obesity were defined using IOTF cut-off points. Underweight was classified using the 5th percentile cut-off point for weight for age, based on the 2000 CDC Growth Reference.

Results: The findings indicated that the significance of overweight and obesity in preschool children in urban areas of HCMC is not only in its magnitude (obverweight: 20.5% and obesity: 16.3% in 2005), but also in the rapidly increasing trend in prevalence from 21.4% in 2002 to 36.8% in 2005.

There exists an imbalance in food intake in this young child population. Dietary patterns have shifted towards higher energy obtained from protein and fat (particularly animal protein and fat) and less energy from carbohydrates, than is recommended.

The risk factors of overweight and obesity in the four to six year old child population in HCMC were identified at multiple levels. The contextual variables in the community, school and home environments, interacted with individual characteristics influencing the changes in adiposity and overweight and obesity development over time. Risk factors for changes in adiposity and risk of developing overweight and obesity differed for boys and girls.

The proxy-questionnaire was shown to be valid for ranking the child's sedentary behaviour but it was not suitable for measuring the child's physical activity patterns in absolute values.

Conclusion: An obesity epidemic has been taking place in the young child population in urban areas of HCMC. Boys appear to be more vulnerable to this epidemic than girls. The diet of this child population has shifted to higher energy from protein and fat, and less energy from carbohydrate. The aetiology of overweight and obesity of preschool children is multi-factorial. It is time for action to control this public health problem in young children in urban areas of HCMC, Vietnam.

Chapter 1 Introduction

1.1 Background

Childhood obesity has become a global health problem. It is already an epidemic in industrially developed countries and is on the rise in the developing world (Lobstein et al., 2004, Wang and Lobstein, 2006). According to the estimates provided by the World Health Organisation (WHO), there are at least twenty million children under five years of age worldwide, who are overweight (WHO, 2003). The trends in overweight and obesity in preschool children continue to increase in the developed world (Kalies et al., 2002, Vaska and Volkmer, 2004, Stamatakis et al., 2005, Cynthia et al., 2006) and similar patterns have been reported in a number of lower and middle income countries during past decade (Chu, 2001, Kosulwat, 2002, Noor, 2002, Wang et al., 2002, Wang and Lobstein, 2006).

The situation of childhood obesity in developing countries appears to be more complicated because of the co-existence of both over-nutrition and under-nutrition (Doak et al., 2000, Popkin et al., 2001, Popkin, 2002b, Lobstein et al., 2004). This situation is known as “nutrition transition” and is documented in developing countries that are undergoing urbanization and industrialization (Popkin, 1999, Popkin and Gordon-Larsen, 2004, Mendez and Popkin, 2004). Rapid economic and social development have led to changes from traditional lifestyles toward Western lifestyles, with high energy and fat dense diets, increases in sedentary behaviour and lower levels of physical activity (Noor, 2002, Popkin, 2003). Obesity can be seen as a normal physiological response to a “pathological obesogenic environment” when the environment promotes excessive food intake and discourages physical activity (Hill and Peters, 1998). The environmental factors promoting overeating, such as readily available food, large portion sizes and high-fat diets provide more opportunities for the consumption of large quantities of food high in energy and fat. Environmental factors may also play a role in promoting a sedentary lifestyle and decreased energy expenditure such as TV viewing, video and computer game playing (Dietz and Gortmaker, 2001). Furthermore, the changing nature of neighbourhood safety and community structures has promoted vehicle use and contributed to reduced physical activity such as walking to school or to doing errands with parents or visiting friends as part of daily life (Dietz and Gortmaker, 2001).

In recent years, the economic status of Vietnam, a developing country in the Southeast Asian region, has improved considerably and its economy has undergone rapid industrialization, especially in the urban areas. Ho Chi Minh City (HCMC) is the largest city in Vietnam and has the highest rate of economic development in the country. During the past decade, the city's annual Gross Domestic Product (GDP) growth rate has been estimated at over 10% and account for 20% GDP of the country (Statistical_office_HCMC, 2005). These changes have produced effects on the nutritional status of children similar to those seen in other developing countries undergoing a “nutrition transition” (Popkin et al., 2001, Wang et al., 2002). Under-nutrition, the major health problem for Vietnam in 1980s, has been partially resolved but now co-exists with over-nutrition, which is rapidly becoming an important public health problem in urban populations. Results from cross sectional nutrition surveys conducted over the last six years in HCMC have revealed this trend, and given evidence of a nutrition transition taking place in children. The prevalence of overweight (defined as weight for height index > +2 Z score based on 1978 NCHS/WHO international growth reference) of primary school children in the year 2002 was 9%, approximately 3% higher than that observed in similar surveys conducted in the year 2000 using the same criteria for defining overweight (Loan et al., 2003b). Furthermore, in 2002 in the same population, 9% of the children were also malnourished (defined as weight for age index < -2 Z scores based on 1988 NCHS/WHO international growth reference). A survey in 2002 on the nutritional status of preschool aged children from kindergartens in Ho Chi Minh City reported a prevalence of overweight (defined as weight for height index > +2 Z score based on 1978 NCHS/WHO international growth reference) of 7.8% (Hung et al., 2003). In a rapidly changing society, it is likely that the effects of altered environments and lifestyles will initially appear in the youngest children (Dietz and Gortmaker, 2001).

Childhood obesity has produced profound consequences on health and economic aspects in countries with an obesity epidemic. Recent reviews estimating the number of children with obesity related diseases risk factors and co-morbidities in Europe, have shown a very high estimated number of obese and overweight children who have at least one indicator of metabolic syndrome or cardiovascular disease, such as impaired glucose tolerance, type 2 diabetes, hypertension and elevated blood cholesterol levels (Lobstein et al., 2004, Wang and Lobstein, 2006). This implies that in the near future there will be enormous healthcare costs attributed to childhood obesity as a result of the substantial increase in obesity-related chronic disease in young adults. Although obesity in early childhood is not as strong a predictor for adult obesity as is adolescent obesity, it has been shown to be linked with subsequent adverse health consequences, and may persist into adolescence and adulthood, especially among older preschool children (Serdula et al., 1993, Dietz, 1998, Parsons et al., 1999, Reilly et al., 2003b, Lobstein et al., 2004, Lobstein and Jackson-Leach, 2006).

It has been suggested that prevention of obesity in children is the only feasible solution to combat the obesity epidemic in developed and developing countries (Lobstein et al., 2004). It is therefore crucial to identify risk factors for early onset childhood obesity in order to design effective prevention programs for the control of this potential obesity epidemic. Almost all studies on nutritional status of preschool aged children in HCMC have been cross-sectional in design and therefore cannot provide cause and effect conclusions about factors related to obesity in the children studied. This study will evaluate the extent of overweight in preschool children and trends in overweight among this population during the past three years. It will identify the risk factors for early onset overweight in early childhood and describe the microenvironments, diets and patterns of physical activity of preschool aged children in urban areas of Ho Chi Minh City.

1.2 Aims of the project

1.2.1 Overall aim

This one year follow-up study aims to identify the risk factors at community, preschool, family environments, parental characteristics, and the child' characteristics associated with changes in adiposity (BMI, skinfold thickness) in children aged four to five years over the one year period. The prevalence of overweight and obesity in 2005 using data from the baseline data and the trends in overweight and obesity in this child population over the three year period (2002 to 2005) was also examined. Additionally, a proxy-questionnaire for measuring physical activity of preschool children was validated in a sub-study integrated in the cohort study.

1.2.2 Specific aims

1) To examine the prevalence of overweight/ obesity, underweight, stunting and wasting in 2005, based on the baseline measurement from the cohort study. In addition, the cross sectional relationship between a number of potential risk factors and overweight and obesity in preschool children were also examined (Chapter 4).
2) To assess the trends in overweight and obesity in urban preschool children in HCMC over a period of three years (based on the available data from the 2002 cross-sectional study and baseline measurements for the cohort study) (Chapter 5).
3) To validate a proxy-questionnaire assessing the physical activity in preschool children in the cohort study (Chapter 6).
4) To describe the nutrient intakes and food patterns in children aged four to five years in urban preschool children in HCMC (Chapter 7).
5) To examine the risk factors including community, preschools, home environment factors, socio-demographic characteristics, the diet and physical activity patterns and individual's characteristics, associated with longitudinal changes in indicators of adiposity (BMI and skinfold thickness) over a one year period in children aged four to five years in urban areas of HCMC (Chapter 8).

1.3 Thesis structure

This thesis consists of eight chapters:

Chapter 2 reviews issues related to childhood obesity. First is a description of the magnitude of preschool child obesity in Asian nations, including Vietnam, during the past decade. Then, the potential risk factors for young childhood obesity are reviewed. The methods universally used to assess overweight and obesity in childhood are also summarised.

Chapter 3 describes the methods used in this project as well as providing a detailed prescription of the data sources and analysis strategies used to address the research questions. The study design and data collection methods on anthropometry, dietary intake, and physical activity are presented and the specific strategies for using the collected data to answer the thesis aims are explained. The method of conducting the 2002 cross-sectional study on nutritional status of kindergarten children is also described in this chapter.

Chapter 4 presents the findings of the baseline study. The cross-sectional association between socio-demographic factors and overweight/ obesity among this population is also examined.

Chapter 5 examines the trends in overweight/ obesity among preschool children in urban areas of HCMC over a 3 year period, based on data from a 2002 cross-sectional survey and baseline measurements from the cohort study.

Chapter 6 provides the methods and the results of a validation study of the physical activity questionnaire for preschool children.

Chapter 7 provides the results of dietary intake and describes the dietary patterns of children aged four to five years in the study.

Chapter 8 identifies the risk factors associated with changes in indicators of adiposity over a one year follow-up period. These include dietary intake, physical activity, microenvironments in homes, preschools, local neighbourhoods, socio-demographic, and feeding practices in the infant period. Analytic approaches to modelling risk factors for overweight in preschool children are also presented.

Chapter 9 summarises the results from Chapters 4 to 8, to identify the main characteristics of the overweight and obesity problem in preschool children in urban areas of HCMC. Limitations of this project will be considered and proposed future research needs are presented in this chapter.

1.4 Significance of thesis

This is the first longitudinal study to examine the cause and effect associations of factors potentially related to overweight/ obesity in preschool aged children in Ho Chi Minh City and in Vietnam. In this study, a wide range of potential factors associated with early childhood overweight/obesity are fully assessed. It provides the first detailed description of diet and physical activity in this population. There has been no prior evaluation of trends in overweight and obesity in preschool children in Ho Chi Minh City and this topic will be assessed in the thesis to determine the speed of expansion and the current level of this trend. The findings of this thesis will provide important information that will help health policy makers design effective obesity prevention programs in urban cities in Vietnam.

Chapter 2 Literature review

2.1 Childhood obesity in the developing world and in Vietnam

2.1.1 Nutrition transition in the developing world and in Vietnam

During the past two decades, there have been large changes in the nutritional status of children and adults in developing countries. In many middle and lower income countries in Latin America, Africa, the Middle East and Asia, a decline in under-nutrition and a parallel increase in overweight has been observed among adolescents and adults (Popkin, 1994, 2002b, Monteiro et al., 2002, Kosulwat, 2002, Noor, 2002, Rivera et al., 2004, Mendez et al., 2005). Although under-nutrition remains a public health problem in those countries, particularly in rural areas, the rise in the prevalence of overweight and obesity, along with a trend towards an increasing prevalence of non-communicable diseases among urban populations, has raised concern about obesity-related chronic disease.(Popkin, 2002b).

The process of such change in nutritional status in middle and lower income countries, has been termed the "nutrition transition". The underlying changes in socioeconomic and demographic factors associated with a shift in diet and physical activity patterns, have been proposed as the main causes for this transition (Popkin, 1994, 1999, Popkin and Gordon-Larsen, 2004). Further analyses on the mechanism of these trends indicate that globalization and urbanization play important roles, including changes in dietary habits and physical activity patterns (Popkin, 1999, Ulla et al., 2002, Mendez and Popkin, 2004).

Globalization is a process whereby increasing economic, political and social interdependence and global integration take place in terms of capital, traded goods, persons, concepts, images and ideas (Ulla et al., 2002). Increased globalization has led to exposure to the global media, shifts in occupations including a trend from labour-intensive occupations and leisure time activities towards more capital-intensive, less strenuous work and leisure activity (Ulla et al., 2002). Urbanization brings shifts to modern lives such as access to mass media, modern technologies serving work, leisure and transportation needs, and enhanced access to a variety of foods across all seasons of the year (Mendez and Popkin, 2004). Other analyses of economic and food availability data from 1962 to 1994, and of shifts in the structure of global diets, have indicated that with high rates of urbanization, diets were predicted to shift to a substantially higher level of consumption of sweeter and fatter foods (Drewnowski and Popkin, 1997). Globalization and urbanization, therefore, have impacts on changes in dietary habits and patterns of physical activity and are responsible for changes in nutrition in developing nations.

There are a number of important characteristics of the process of a nutrition transition in the developing world. Firstly, the changes in traditional diets towards a Western diet high in saturated fat, sugar and refined foods but low in fibre, and the changes in physical activity towards sedentary patterns, are occurring faster in developing countries than in developed countries in the past (Popkin, 2002b). The process of such changes in middle and lower- income countries has taken one or two decades while the same processes occurred over many decades or centuries in Western countries (Popkin, 2002b). Furthermore, the prevalence of obesity across all age groups of the population in developing countries has increased at a rapid rate over the last two decades and the average rate of increase in the proportion of overweight in several of those countries may be comparable to the United States (Popkin, 2002b). Overweight is found to exceed underweight among young women aged 20 to 49 years in analyses on patterns of overweight and underweight among women in the developing world (Mendez et al., 2005).

The situation appears to be more complex when both overweight and underweight exist in the same country, even in the same household (Doak et al., 2000). Another important highlighted point is that stunted children are more likely to become overweight than non-stunted children (Popkin et al., 1996, Sawaya et al., 1998, Benefice and Garnier, 2001, Martins et al., 2004). Since stunting is still common and affects about 30% of children under 5 years of age in developing countries (UNICEF, 2006), it may be a potential cause for an increase in the prevalence of overweight in children in developing nations that are adopting Western lifestyles with high energy diets and low levels of physical activity.

A significant increase in the number of people in the developing world who suffer from non-communicable diseases has been observed and this has been occurring in tandem with the process of the nutrition transition. It has also been suggested that biological features, such as ethnicity and genetics, have an impact on changes of body composition, leading to greater susceptibility to chronic disease (Popkin, 2002b).

There is extensive evidence of remarkable change in nutrition outcomes resulting from the adoption of Western dietary and physical activity patterns in Latin America, Africa, the Middle East, and Asia. Progress has been made in reducing child malnutrition over the past few decades in most developing countries but this has been coupled with a rapid shift to overweight in children and adults, particularly in countries with rapidly growing economies. The prevalence of stunting has fallen in the developing world from 47% in 1980 to 33% in 2000, although progress has been uneven between regions (de Onis and

Blossner, 2000). In addition, the prevalence of underweight has declined from 44% in 1996 to 27% in 2004 (UNICEF, 2006) with the sharpest declines in child malnutrition in the East Asia and Pacific regions (UNICEF, 2006). In parallel with these changes in the developing world, a rapid rise in overweight in children and adults has been observed. The highest levels of obesity have been observed in the Middle East, Western Pacific and Latin America where a nutrition transition began last century (Popkin, 2002a). A progressive increase in the prevalence of obesity in children and adults has also been reported in Asia, particularly in higher income developing countries including Japan, South Korea, Thailand, and Malaysia (Popkin, 1994, Popkin, 1997, Popkin, 2002a, Kosulwat, 2002, Noor, 2002).

Vietnam, a South-East Asian country, is experiencing the early stages of a nutrition transition. Since economic reforms began in 1985, Vietnam has achieved a rapid level of economic development with increasing annual GDP. These economic achievements have produced effects on the nutritional status of the population and the structure of their diets. Under-nutrition, a public health problem in 1980s, has improved considerably. According to national surveillance data on the nutritional status of children , the proportion of children under 5 years of age who are stunted (defined as height-for-age index <-2 Z-scores/ 1978 WHO international growth reference) has decreased significantly from 59.7% in 1985 to 29.6% in 2005 with an average reduction of 1.5% per year over this period and with the highest rate of reduction in urban regions (Khan et al., 2006).

The structure of the Vietnamese diet has also changed markedly over past two decades. The daily average intake of animal products, especially meat has increased (meat intake from 24 grams/ day in 1990 to 51 grams/ day in 2000). The percentage of energy from fat has also increased from 6% (1990) to 12% (2000) and to over 20% for many urban populations (Khoi and Khan, 2004).

Over-nutrition was not thought of as a public health problem in Vietnam, even in urban regions, until the late 1990s when studies focusing on over-nutrition noted that excess weight was appearing in children and adults in Ha Noi and Ho Chi Minh City (HCMC), the largest and most developed cities in Vietnam (Khoi, 2002). The prevalence of overweight[1] in children from 6 to 17 years of age in Ha Noi City rose from 2.6% in 1995 to 5.6% in 2000. In the same population, the prevalence of stunting, underweight and wasting was also high (8.6%, 8.5%, and 10.6% respectively) (Lien et al., 2002). Among adult populations in urban areas of Ha Noi, the percentage of adults who had BMI $\geq$ 25 kg/m^2 increased rapidly from 1.5% in 1995 to 18.47% in 2003 (Mai et al., 2003). A similar trend in nutrition patterns has been observed in HCMC. In a cross sectional study of the nutritional status of adults living in HCMC in 2002, the prevalence of overweight (BMI $\geq$ 25 kg/m^2) in adults aged 15 and over was reported to be 15.7% but the percentage of adults suffering underweight (BMI < 18.5 kg/m^2) was also high at 21.3% (Loan and Hung, 2002).

Another study in 2004 focused on the prevalence of overweight in the urban adult population aged 20 to 60 years in HCMC and revealed that 17.2% were overweight (BMI $\geq$ 25 kg/m^2) (Cuong, 2004). It appears that overweight has increased faster in children in HCMC. The prevalence of overweight (defined as weight-for-height index > +2 Z-scores of 1978 WHO reference population) in grade 1 and 2 children in HCMC has nearly doubled from 3.9% in 1999 to 6.0% in 2000 (Loan and Hung, 2002).

[1] *Overweight defined as weight-for-height index >+2 Z-scores based on the 1978 WHO reference population for children < 9 years old and age and sex specific BMI ≥ 85th percentile of 1978 WHO reference population for children ≥ 9 years old*

The changes in socio-economic status and lifestyle have effected not only nutrition but also disease patterns in Vietnam. In recent years, non-communicable diseases such as diabetes, hypertension, and dyslipidemia have become public health problems, particularly in urban populations (Khoi, 2002). A study in 2001 revealed the crude prevalence of diabetes among adults in HCMC (6.9%) was approximately 2.8 times higher than that reported in a 1993 study (2.5%) and that overweight (BMI > 25kg/m^2) and high waist to hip ratio were positively associated with diabetes (Duc Son et al., 2004). Furthermore, a study on metabolic syndrome (defined as the presence of three or more of the following components: abdominal obesity, hypertriglyceridemia, low HDL-cholesterolemia, high blood pressure and high fasting plasma glucose) reported that 12.0% of the urban adult populations of HCMC had metabolic syndrome (Son Le et al., 2005). Other studies have shown that non-communicable diseases have become more common as chronic disease among adults in HCMC (Hanh et al., 2002, Cuong, 2004). These findings suggest a shift towards over-nutrition-related diseases emerging in urban adult populations in Vietnam.

These findings suggest that Vietnam is undergoing the early stages of a nutrition transition and will increasingly face a number of public health problems commonly seen in developed countries. This is the same changing public health picture that can be seen in other rapidly growing countries in Asia, such as Thailand, Malaysia and China.

2.1.2 Childhood obesity in the developing world and in Vietnam

Currently, childhood obesity has increased worldwide with differing rates in various regions of the world. This health problem has spread at a rapid rate in the industrially developed countries over the last two decades and has become more prevalent in developing nations that are undergoing profound economic changes (Lobstein 2004, Wang 2005).

In the developing world, shifts towards obesity compared to underweight in children, appeared to take place at a more rapid rate in the Latin American countries and the Middle East. The prevalence of overweight or obesity in school aged children in Brazil, using the International Obesity Task Force (IOTF) criteria, has more than tripled over the period 1974 to 1997 from 4.1% to 13.9% (Lobstein et al., 2004). A report on the trends in overweight among Brazilian preschool children has shown a remarkable increase in overweight (using 1978 WHO definition) in young children from higher income families in the more developed south-eastern regions of Brazil where the prevalence of overweight has increased from 2.8% in 1989 to 6.8% in 1996 (Monteiro et al., 2002). Similarly, a rising trend in childhood obesity in Chile has been observed. The proportion of children aged 6 years affected with overweight based on IOTF reference population, has risen from 12% to 26% in boys and 14% to 27% in girls between 1987 and 2000 (Lobstein 2004). Younger children in Chile seem to be less effected by this epidemic. The prevalence of overweight in children under 5 years old, using the 1987 WHO definition, has increased from 4.2% in 1988 to 5.3% in 1999 (Rivera et al., 2004).

In the Middle Eastern region, Egypt has reached a level of preschool obesity comparable to that of industrialised countries. The prevalence of overweight has rapidly escalated from 2.2% in 1978 to 8.1% in 1996 (de Onis and Blossner, 2000). A highly unexpected obesity prevalence in children aged 2 to 5 years was found in rural provinces of Iran in 1995, irrespective of the obesity classification system used. Based on the international definition for overweight and obesity (Cole et al., 2000), 23.5% of children aged 2 to 3 years were considered to be overweight and 10.9% of these children obese, while 18.3% and 7.5% of children aged 4 to 5 years were overweight and obese respectively (Dorosty et al., 2002).

The spread of the childhood obesity epidemic in Asia appears to be slower than that observed in the Latin American and the Middle East (Lobstein et al., 2004). Results of a study on child nutritional status in China over the period 1989 to 1997, have indicated a rising percentage of children who have excess weight, especially in urban areas (Luo and Hu, 2002). Over this period, the overweight prevalence among children aged 2 to 6 years, using the IOTF definition, has risen from 4.2% to 6.4% (Luo and Hu, 2002). A profound increase was found in urban areas where this percentage has risen from 14.6% to 28.9% over this period. Also in this population, analyses of changes in BMI during eight years of follow-up have shown a shift in body composition, with annual average increases in BMI of 0.2 kg/m^2 in urban areas and 0.1 kg/m^2 for children from rural areas (Luo and Hu, 2002).

In Taiwan, an increasing trend in obesity in school aged children has been noted over the last decade, with obesity being more prevalent in boys than in girls (Chu, 2001). The prevalence of obesity (defined as body weight > 120% of mean body weight of age and gender- specification) has increased from 12.4% in 1980 to 16.4% in 1996 for boys, while it has been relatively stable for girls (10.1% and 11.1% respectively) (Chu, 2001).

Coinciding with a rapidly growing economy in Thailand have been changes in lifestyle and nutrition patterns seen in both adults and children. A survey on obesity among preschool children in the Saraburi Province, a central region of Thailand, has shown a high percentage of children affected by obesity (defined as weight-for-height index > 97th Thai reference population), particularly in urban areas where 22.7% of preschoolers in urban areas and 7.4% of those in rural areas were classified as obese (Sakamoto et al., 2001).

A similar shift in over-nutrition in young children was observed in other countries in South East Asia. National data on the nutritional status of children under five years of age in Brunei Darussalam in 1997 revealed a proportion of children who had weight-for-height index > +2 Z-scores (based on 1978 WHO reference population) ranging from 7.7% to 10.2% in different parts of the country (Tee, 2002). Malaysia has been experiencing a nutrition transition since the 1990s, with evidence of changes in dietary and physical patterns coupled with a shift in nutrition patterns and nutrition related health problems (Noor, 2002). Results from a survey carried out among school aged children in Kuala Lumpur in 1998 showed an increasing prevalence of overweight with age (using the 1978 WHO criteria) in which the percentage of overweight was least prevalent among 7 year old children (6.6%) and was most common among 13 year old children (13.8%) (Noor, 2002). Childhood overweight has therefore become an epidemic in the developing world although the magnitude and context of this health problem differs by region.

With data collected for the World Health Organization's Burden of Disease Program from industrialised countries and a number of developing countries, the global prevalence of overweight and obesity has been estimated for 2006 and projected for 2010 (Lobstein and Jackson-Leach, 2006) (see Table 2-1). Although data on overweight and obesity in developing countries is limited, these estimates have illustrated a growing global childhood obesity epidemic that requires urgent global, national and regional level intervention programs (Wang and Lobstein, 2006).

Table 2-1 Prevalence of overweight and obesity in school-aged children

Prevalence of overweight and obesity in school-aged children based on latest available data and the IOTF criteria, with estimations for 2006 and 2010 based on population-weighted annualized increases in prevalence

WHO Region (dates of most recent surveys)	Most recent surveys		Projected 2006		Projected 2010	
	Overweight (inc obesity) %	Obesity %	Overweight (inc obesity) %	Obesity %	Overweight (inc obesity) %	Obesity %
Africa (1987 - 2003)	1.6	0.2	*	*	*	*
America (1988 - 2000)	27.7	9.6	40.0	13.2	46.4	15.2
Eastern Med (1992 - 2001)	23.5	5.9	35.3	9.4	41.7	11.5
Europe (1992 - 2003)	25.5	5.4	31.8	7.9	38.2	10.0
South East Asia (1997 - 2002)	10.6	1.5	16.6	3.3	22.9	5.3
West Pacific (1993 - 2000)	*12.0*	*2.3*	*20.8*	*5.0*	*27.2*	*7.0*

Source (Wang and Lobstein, 2006)

At a national level, over-nutrition in children has not been considered a public health issue in Vietnam (de Onis and Blossner, 2000, Wang and Lobstein, 2006). However, available data collected in recent years (Table 2.2) has implied that obesity is emerging as a great concern in children in the largest cities of Vietnam, where the highest rates of economic development have occurred, along with profound changes in the environment and lifestyle.

As shown in Table 2.2, the prevalence of overweight in children is increasing in Vietnam. The estimate of overweight in school children has doubled over a time period of four years in Nha Trang City (Bao et al., 2002), or tripled over a five year period in District 1 of HCMC (Loan et al., 2003). Similar trends were observed for prevalence of overweight in adolescents in urban areas of HCMC with an increase of 2.5 times from 2002 to 2004 (Hong, 2005). Across the regions in Vietnam, the spread of childhood obesity seems to be faster in HCMC than any other Vietnamese city over the last ten years. The prevalence estimate was observed to be much higher in the urban areas of HCMC where it has reached more than 20% in school children in wealthy region such as District 1 of HCMC (Loan et al., 2003).

Table 2-2 Trends in childhood overweight and obesity in Vietnam

Regions (sources)	Time frame	Age group (ys)	Sample size	Sampling - Study design- Representativeness	Trends in prevalence of overweight (%)	Definition of overweight
Ha Noi City (Lien et al., 2002)	2000	6-11	NA*	Multistage sampling Cross-sectional study City level	8.8	1
Nha Trang City (Bao et al., 2002)	1997 to 2001	6-11	NA*	Multistage sampling Cross-sectional study City level	2.1 to 5.9	1
	1997	3-6	NA*		4.3	2
District1, HCMC (Loan et al., 2003)	1997 to 2002	6-11	911/1627	Multistage sampling Cross-sectional study Regional level	12.2 to 22.7	1
Urban HCMC (Hong, 2005)	2002 to 2004	11-16	1003/2684	Multistage sampling Cross-sectional study Regional level	5.6 to 13.7	3
Go Vap District, HCMC (Huong and Hung, 2002)	2001	1-6	NA*	All children aged 1-6 years in preschools participated Regional level	7.9	2
Overall HCMC (Hung et al., 2003)	2002	1-6	1780	Multistage sampling Cross-sectional study City level	7.8	2
Overall HCMC (Vu et al., 2006)	1996 to 2005	0-5	1782/1790	Multistage sampling Cross-sectional study City level	2.0 to 6.0	2

NA Not available*

1. *Overweight defined as weight-for-height index >+2 Z-scores based on the 1978 WHO reference population for children < 9 years old and age and sex specific BMI ≥ 85th percentile of 1978 WHO reference population for children ≥ 9 years old*
2. *Weight-for-height index >+2 Z-scores (the 1978 WHO reference)*
3. *IOTF*

The importance of overweight in preschool children appears to less prominent compared with that in older children. Two cross-sectional studies carried out in preschools in one district or overall in HCMC has yielded a similar result about 7.8% for children who had weight for height z-score >+2SD of the 1978 WHO reference population (Huong and Hung, 2002, Hung et al., 2003). Using the same growth reference a lower percentage of children (6% in 2005) was categorized as overweight in the community setting in HCMC compared with the results from the preschool setting. However, the estimates in the community have tripled between 1996 to 2005 (Vu et al., 2006). Additionally, this has been coupled with a marked decrease in underweight in the same period (28.5% to 10.8%) (Vu et al., 2006).

At the present, data of childhood obesity in Vietnam are from cross-sectional studies using multi-stage sampling. Furthermore, using different cut offs to classify overweight and obesity and different growth references have resulted in inconsistence in the results and difficulty in compariing and monitoring the prevalence of overweight and obesity.

Nevertheless, the available evidence on levels of overweight in the young child population in HCMC, suggests that it is time for action to help allay this future public health problem. This action should begin by identifying the risk factors for excess weight gain in order to help design effective prevention programs.

2.2 Conceptual framework of risk factors for childhood obesity

It has been suggested that epidemiological studies should move beyond the individual characteristics or behaviour to health contextual influences, in order to strengthen the research investigating the determinants for an individual's health outcome (Diez-Roux, 1998). Since the inter-relationship between these determinants are complex, building a conceptual framework of potential predictors for the research outcome in epidemiological studies is very important in terms of navigating the pathway to conduct studies and assisting the analytical approach (Victora et al., 1997). Furthermore, a comprehensive framework of disease causation should integrate individual-level and group-level variables (Diez-Roux, 1998).

The aetiology of obesity is proposed to be multifactorial, where both genetic factors and environments promoting excess food intake and low level of physical activity, have been identified (WHO, 2000). Based on the Ecological System Theory (EST), a contextual model for childhood overweight has been proposed for the use in childhood obesity studies

(Davison and Birch, 2001b). In this model, child behavioural patterns such as dietary intake, physical activity and sedentary behaviour, referred to as overweight child risk factors, are moderated by the child's biological characteristics and interact within and among other contexts including parental characteristics, family environment and community and societal characteristics (Davison and Birch, 2001b).

Victora et al (Victora et al., 1997) have developed an hierarchical conceptual framework to study a disease's determinants. In this conceptual framework, context-related factors such as socioeconomic or environmental factors, referred to as distal determinants, influence child health through a number of inter-related proximal determinants (Victora et al., 1997). This conceptual framework provides guidance for the analytical approach to identify the risk factors. It is not based entirely on statistics and allows interpretation of the findings in light of social and biological knowledge (Victora et al., 1997). In addition, the effect of risk factors on a child health outcome is adjusted for confounding factors or mediated through intermediate variables (Victora et al., 1997). For these reasons, this hierarchical conceptual framework has been commonly used for studies of childhood obesity (Borges Neutzling et al., 2003, Hong, 2005, Ming, 2006, Hallal et al., 2006).

Based on the results of research assessing the risk factors of childhood obesity and the suggested hierarchical conceptual framework for the disease causation model above (Victora et al., 1997), the present study employed a conceptual framework for risk factors for developing obesity in preschool aged children in HCMC. This framework provides guidance for a comprehensive assessment of causation for the obesity epidemic in this population that allows for the formulation of an evidence-based prevention program in the future. A review of the predictors of childhood development in terms of a child's level of variables, and groups of contextual variables, is presented in the next sections.

2.3 Review of risk factors for overweight and obesity in children

Childhood development has it origins very early in life from the in utero period (Whitaker and Dietz, 1998). A review of risk factors for childhood obesity needs to begin with the foetal-related factors at the child characteristics level. The child's dietary and physical activity behaviour, parental characteristics, socio-demographic factors and family, school and community environments are then reviewed.

2.3.1 Perinatal characteristics, growth and maternal practices

Size at birth is a reflection of the child's growth during pregnancy. Both low and high birth weight, and accelerating growth early in life have been highlighted as likely to increase the risk of later obesity (Whitaker and Dietz, 1998, Martorell et al., 2001, Oken and Gillman, 2003, Monteiro and Victora, 2005, Baird et al., 2005, Samaras and Elrick, 2005, Victora et al., 2007).

There is abundant evidence highlighting a direct relationship between high birth weight and later obesity, although most of these studies are limited by a lack of control for potential confounders including gestational age, birth length, parental body size, tobacco use, and socioeconomic status (Oken and Gillman, 2003).

A large cohort study undertaken with Scottish children born in 1994 or 1995 demonstrated that higher birth weight ($\geq$ 4000 grams) was significantly and positively associated with obesity at 39 to 42 months, after adjusting for socioeconomic factors (Armstrong and

Reilly, 2002). In the Avon longitudinal cohort study, each additional 100 grams of birth weight had an associated increased risk of 1.05 (95% CI: 1.03, 1.07) of obesity in children at age 7 years (Reilly et al., 2005).

Birth weight has also found to be positively associated with overweight and obesity at 5 and 14 years of age in a population-based birth cohort in Brisbane, Australia after adjusting for socioeconomic status and parental BMI (Mamun et al., 2005). Recently, a longitudinal study undertaken in Canada reported that higher birth weight children (>4000 grams) with a non-smoking mother were more likely to be overweight at 4.5 years old than children who were lighter at birth. This likelihood was strongest when these children experienced the greatest weight gain in the first months of life (Dubois and Girard, 2006).

There is increasing evidence that children and adults who are born with a low birth weight are more likely to accumulate central fat compared with those who have normal weight at birth. (Strauss, 1997, Barker et al., 1997, Bavdekar et al., 1999, Byberg et al., 2000, Okosun et al., 2000, Yajnik, 2000, Garnett et al., 2001, Yajnik, 2004a, Ong, 2006, Rogers, 2003). A comparison of body composition between newborn Indian babies and white babies born in Southampton, UK, has shown that the Indian babies were small in all respects (birth weight, head circumference and length), but the subcutaneous fat levels in both groups were similar (Yajnik, 2004).

Similarly, in the third National Health and Nutrition Examination Survey (NHANES III 1988-1994), children born small for gestational age (SGA, defined as a birth weight < 10^{th} percentile) remained slightly smaller than those who had normal birth weight but had a higher fat percentage, due to reduced lean tissue mass without a reduction in fat mass (Ong, 2006). Another survey that focused on the effect of low birth weight on later health status among 8 year old Indian children, reported that poor intrauterine growth was related to central fat (subscapular: triceps skinfold thickness) and increased postnatal weight gain exaggerated this relationship (Yajnik, 2000). Similarly, a recent study has shown that the accumulation of excess central fatness continues, over the following 2 years, in children who were born small and completed the postnatal growth catch-up at the age of 2 years, although there was no further catch-up in overall height or weight (Ong, 2006).

Central obesity is known to be a risk factor for developing cardiovascular disease including hypertension, dyslipidemia, hyperinsulinemia and impaired glucose tolerance which has been termed as insulin resistance syndrome or "Syndrome X" (Despres and Lemieux, 2006). Thus, being born small, a consequence of foetal growth restriction, followed by a postnatal catch-up growth under normal re-nutrition, is considered to lead to a greater risk of gaining excess adiposity. These changes in adipose tissue have long-term functional consequences later in life, including early development of insulin resistance (Levy-Marchal and Czernichow, 2006).

After adjusting for potential confounders such as socioeconomic and maternal factors, it has been demonstrated that rapid growth in the first years of life increases the risk of obesity in childhood, adolescence, and early adulthood with or without the contribution of birth size status (Monteiro and Victora, 2005, Baird et al., 2005). A recent systematic review evaluating 13 studies on the effect of rapid growth in infancy with the risk of overweight or obesity at ages three to 70 years, reported that all these studies found a significant association between infant weight gain with later obesity risk, regardless of the obesity definition used (Monteiro and Victora, 2005). A systematic review of 24 studies reported the effect sizes of the association between infant size or infant growth and obesity in the future. Children who were obese or who were at the highest end of the weight distribution in the infant period, had odds ratios of 1.35 to 9.38 for being obese at age 5 to 7 years, compared to non-obese infants (Baird et al., 2005). Furthermore, the odds ratio of being obese in childhood ranged from 1.06 to 5.70 in infants who grew more rapidly (Baird et al., 2005).

In addition to foetal life, early adiposity rebound has been described as another critical period associated with later obesity and unfavourable diseases such as hypertension, impaired glucose tolerance, and diabetes in childhood and adulthood (Rolland-Cachera et al., 1984, Whitaker et al., 1998, Bhargava et al., 2004, Taylor et al., 2005). Adiposity rebound has been proposed as the onset of the second period of rapid growth in body fatness, measured by direct or indirect methods, that occurs between 5 to 7 years of age (Rolland-Cachera et al., 1984). Recently, a review on the effect of early adiposity rebound on health status in childhood and adulthood, indicated that changes in adiposity composition, measured by BMI, during this period was due to a higher than average deposition of weight rather than the slowing of the rate of height gain (Taylor et al., 2005). Furthermore, the increased weight gain resulted from the rapid deposition of fat rather than lean tissue and the rate of gaining fat mass in children who had experienced early adiposity rebound, was almost three times greater than those who were late rebounders (Taylor et al., 2005).

It has been suggested that a number of factors related to maternal practices are associated with perinatal child characteristics. These factors include maternal weight gain, smoking during pregnancy, birth order and early child feeding patterns in addition to the contribution of genetic factors (Whitaker and Dietz, 1998, Oken and Gillman, 2003, Lobstein et al., 2004, Ong and Dunger, 2004, Ong, 2006, Ong et al., 2002, Stettler et al., 2000).

In considering the link between large birth size with subsequent obesity, pre-pregnancy obese mothers were observed to have heavier newborns and an increased risk of later obesity in their offspring (Whitaker and Dietz, 1998, Parsons et al., 2001, Baker et al., 2004, Salsberry and Reagan, 2005, Harvey et al., 2007). Furthermore, obese mothers are known to have a higher risk of developing gestational diabetes and this is accompanied by delivering large babies and an increased risk of later obesity and diabetes in their children (Schaefer-Graf et al., 2005, Kieffer et al., 2006, Henriksen, 2006). Maternal weight gain during pregnancy has also shown to be associated with size at birth and risk of their offspring developing obesity in the future (Whitaker, 2004, Oken et al., 2007).

Children who were born to obese mothers diagnosed in early pregnancy (BMI $\geq$ 30 kg/m^2) were more than two times likely to be obese at age 2 to 4 years (Whitaker, 2004). The findings are in line with data from a prospective cohort study examining the relationship between gestational weight gain and child adiposity, after adjusting for potential confounders including parental BMI, maternal glucose tolerance, breast feeding duration, foetal and infant growth and child behaviour (Oken et al., 2007). Greater weight gain in pregnancy was found to be associated with higher adiposity at three years of age, as measured by BMI and the sum of subscapular and triceps skinfold thicknesses (Oken et al., 2007). The risk of being overweight at three years of age in children whose mother gained excess weight in pregnancy, is 4.4 times higher than those born to mothers who gained inadequate weight during pregnancy (Oken et al., 2007).

In contrast with high birth weight children who are nurtured with adequate or over-nutrition in foetal life, children of low birth weight have suffered foetal growth restriction. A variety of maternal factors influencing foetal growth, including poor maternal nutrition, smoking, and alcohol consumption in pregnancy, are associated with small size at birth that later leads to obesity in the offspring (Strauss, 1997, Michael et al., 2004, Valsamakis et al., 2006, Fernandez-Twinn and Ozanne, 2006).

Maternal nutrient restriction during early gestation has been shown to have a profound effect on birth weight and to result in a much greater risk of adult chronic disease and obesity (Painter et al., 2005). Smoking during pregnancy has also been found to have a negative impact on the developing foetus (Strauss, 1997). According to the American Lung Association, maternal smoking accounts for an estimated 20 to 30% of all low or very low birth weight babies (American Lung Association, 2006) and that places the child at an increased risk of developing a number health problems including degenerative diseases, and obesity, later in life (Ng and Zelikoff, 2007). Parity has been suggested as a catch-up growth related factor in young children. This hypothesis has proposed that first born babies are more likely to be restrained in utero, small at birth followed by catch-up growth, compared with siblings of subsequent pregnancies (Stettler et al., 2000, Ong et al., 2002).

Feeding patterns in early childhood have been shown to link rapid growth in the infancy period and early adiposity rebound to the development of later obesity (Ong and Dunger, 2004). There is extensive evidence that breast feeding protects children against later obesity (Arenz et al., 2004, Owen et al., 2005, Harder et al., 2005). Each month of breastfeeding was reported to be associated with a 4% reduction in obesity risk in a meta analysis based on 16 longitudinal studies and one case-control study, investigating the relationship between duration of breast-feeding and risk of overweight (Harder et al., 2005). Another two systematic reviews reported an approximate 20% reduction in the risk of obesity among exclusively breastfed children compared with exclusively formula-fed children (Arenz et al., 2004, Owen et al., 2005). It is proposed that lower energy and protein in breast milk compared to formula milk, is involved in the mechanism by which breastfeeding protects against later obesity (Singhal and Lanigan, 2007).

In line with early protein intake in relation to later obesity, higher protein intake in the first years of life has been reported to be associated with subsequent adiposity. For example, a high protein intake at the age of two years has been found to be related to increased body fatness at eight years of age via an early adiposity rebound (Rolland-Cachera et al., 1995). Similarly, mean protein intake recorded between two and eight years of age has been shown to be a positive predictor of BMI at eight years, in a six year follow-up study (Skinner et al., 2004).

A recent study has reported a significant association between higher protein intake between the ages of 12 and 24 months with higher BMI standard deviation scores at the age of adiposity rebound for girls, but not for boys (Gunther et al., 2006). From these findings, it has been proposed that the relationship between early protein intake and later obesity is possibly due to its effect on earlier adiposity rebound (Newby, 2007).

In summary, in addition to foetal life and adiposity rebound which have been suggested to be critical periods for development of later obesity (Dietz, 1997), increasing evidence has indicated the importance of rapid growth in the first years of life. There are a number of factors that have been found linked with these critical periods. Regardless of the direct relationship of factors such as maternal practices or feeding patterns early in life with later obesity, or indirectly mediated through size at birth or growth pattern in early childhood, they should all be considered when examining the risk factors for childhood development.

2.3.2 Dietary intake and physical activity behaviors

Since obesity is a consequence of energy imbalance between energy intake and energy expenditure, factors relating to a positive energy imbalance are proposed as potential risk factors for developing obesity.

Dietary intake

There has been intensive research work focusing on the relationship between obesity development in childhood and dietary patterns including energy intake, energy density, dietary composition, and dietary behaviours. Total energy intake is of interest because together with energy expenditure, it is one of the main factors of the energy balance equation. Higher total daily energy intake has been reported for obese children compared with normal children in a cross-sectional study in preschool children with Pacific ethnic in New Zealand (Grant et al., 2004). Similar findings were reported in a case control study of Hong Kong Chinese children aged 6 to 7 years (Hui et al., 2003) and in a cross-sectional study focusing on the relationship between diet and juvenile obesity in Canada, after adjusting for activity level (Gillis et al., 2002). However, the latter study was not specifically designed for young children with participants ranging in age from 4 to 16 years (Gillis et al., 2002). Although the association between high total energy intake and childhood obesity was observed in several prospective studies (Obarzanek et al., 1994, Davies, 1997), the mean energy intakes were not significantly associated with changes in weight or BMI over time in other two prospective studies (Maffeis et al., 1998, Magarey et al., 2001).

Energy density is also of concern because it is a key determinant of overall energy intake and therefore of body weight regulation (Livingstone and Rennie, 2006). Both fat and carbohydrate are related to food energy density, although carbohydrate rich foods have lower energy density than fat rich foods (Livingstone and Rennie, 2006). Energy dense foods are palatable and easily overeaten. In addition, fat and sugar consumption together, appears to have a synergistic effect and a strong influence on energy density (Livingstone and Rennie, 2006). Thus, energy dense foods are potential risk factors for the development of excess weight gain and obesity. However to date, no study has examined the relationship between energy dense foods and childhood obesity (Newby, 2007).

Of the different components of diet and their relationship with childhood obesity, fat intake has received more attention than other macronutrients. Fat contributes more calories to total energy intake. Foods with high fat content are more palatable and do not induce as potent a satiety signal or a compensation effect on subsequent energy intake, as do carbohydrates or protein. As such, consumption of a high fat diet may lead to excess body fat (Doucet and Tremblay, 1997). A longitudinal study among children aged 4 to 7 years reported that a higher percentage of energy from fat is associated with an increase of 1.5 standard deviations in the sum of seven skinfold thickness measurements (Robertson et al., 1999). Similarly, a diet with high energy from fat has been shown to be linked to greater adiposity in another prospective study carried out on children aged 5 to 11 years (Maillard et al., 2000). However, no associations or very few significant associations between fat intake or percentage of energy from fat and change in BMI or the child's weight, have been reported in longitudinal studies (Rolland-Cachera et al., 1995, Magarey et al., 2001)

Findings from epidemiological studies have shown that protein consumption in early childhood appears to be more important than in later childhood, in predicting future obesity. This might occur because protein may be involved in programming for later obesity and adverse diseases or possibly be related to adiposity rebound (Newby, 2007).

The inverse relationship between carbohydrate and adiposity has been reported in several studies (Maillard et al., 2000, Skinner et al., 2004). In a cross-sectional study children aged 5 to 11 years, who consumed a diet with a high percentage of energy from carbohydrate, were shown to have lower adiposity (Maillard et al., 2000). Longitudinal carbohydrate intake from age two to eight years has been reported to negatively predict BMI at eight years of age (Skinner et al., 2004). Nevertheless, the role of carbohydrate in relation to childhood obesity has also been considered to be inconclusive in recent review of the literature (Newby, 2007).The non-significant associations were documented in all longitudinal studies except for one six-year follow-up study carried out in two year old children in the US (Newby, 2007).

In addition to evaluating the importance of energy and macronutrients in relation to childhood obesity, consumption of some food groups such as snacks and sweet beverages, and eating patterns, have been shown to be linked to the development of childhood obesity. Snack foods are known to be higher in energy density with high saturated fat and low vitamin and mineral levels (St-Onge et al., 2003). Girls who ate large amounts of snack foods in the absence of hunger are 4.6 times as likely to be overweight at baseline and 2 years later (Fisher and Birch, 2002).

Furthermore, a prospective study of preschool children reported a positive association between consumption, of high fat foods such as potato chips, cookies, chocolate and fried foods, and weight change (Newby et al., 2003). With regard to sweet drink consumption and obesity in children, a prospective cohort study among 10,904 US children aged 2 to 3 years concluded that consumption of sweet drinks increased the risk of being overweight (BMI ≥ 95^{th} percentile) in children at risk of overweight (BMI 85-<95^{th} percentile) at the baseline, as well as the risk of remaining overweight as assessed at the baseline (Welsh et al., 2005).

Also of concern is the marked increase in consumption of fast foods by child and adolescent populations over the last two decades (St-Onge et al., 2003). This trend has had an adverse effect on diet quality of children with increased intake of foods high in energy, fat, carbohydrate, or food with added sugar, sugar-sweetened beverages and decreased intake of fiber content (Bowman et al., 2004). Western fast food is becoming more available and popular in urban populations of developing countries such as China, Malaysia, Thailand (Popkin, 1994, Kosulwat, 2002) . However, the influence of fast food consumption on childhood obesity has not received adequate attention in studies on childhood obesity in these countries.

There have been a few studies examining the association between nutrient intake, diet consumption patterns, and obesity in children in Vietnam. A case-control study investigating the risk factors for overweight primary school children in one urban district of

HCMC, has shown that overweight children have a diet higher in total caloric intake and quantity of fat. They eat more sweets but less fruit and vegetables, compared with control children (Loan et al., 2003a). Soft drink consumption has been found to be positively associated with overweight while more frequent consumption of vegetables or fruit is inversely associated with overweight among the adolescent population in urban areas of HCMC (Hong, 2005).

Although the increasing prevalence of obesity in young children is recognised, there is little known about what the preschool children eat and how balanced are their diet. The 2002 cross-sectional study has provided some qualitative information on the frequency of consumption of a number of high energy foods including sweets, soft-drinks, ice-cream; however, the structure of diet in this child population has not been measured (Hung et al., 2003). The lack of a validated measurement instrument might be one of the reasons. Since the previous studies on obesity in young children were cross-sectional studies, examining the longitudinal dietary intake on weight gain over time in this cohort study, will provide useful findings on the association between food intakes with the development of overweight and obesity in this child population in HCMC.

Physical activity

As with diet, there has been a large number of studies examining the role of physical activity in the development of childhood obesity. In general, lower levels of physical activity and habitual exercise among children are observed to be linked to adiposity and obese status, although the effects identified are generally of small magnitude (Must and Tybor, 2005).

In a cross-sectional study, children in the lowest quartile for vigorous activity assessed by accelerometers, were shown to have on average, 4% greater percentage of body fat than children in the highest quartile for vigorous activity (Janz et al., 2002). Similarly, in a study designed for physical activity assessment, overweight boys, defined as age and gender-specific BMI above 85th percentile of the 2000 CDC growth chart, were significantly less active than their non-overweight peers (Trost et al., 2003).

By employing parent proxy-reporting to measure physical activity in young children, several longitudinal studies have found that high levels of baseline physical activity predict subsequent decreases in BMI after adjusting for confounders (Klesges et al., 1995, Davison and Birch, 2001a). Data on activity monitoring, using a Caltrac accelerometer and anthropometry measures over 8 years, have shown that children in the highest tertile of average daily activity from ages 4 to 11 years, experience consistently smaller gains in BMI, triceps and the sum of five skinfold measurements throughout childhood (Moore et al., 2003).

There is also an increasing number of studies suggesting that sedentary behavior may be partly responsible for the obesity epidemic in children. Common types of sedentary activities that have been used in epidemiological studies on obesity are television viewing or video game/computer use. Cross-sectional studies evaluating the relationship between TV viewing and childhood obesity have reported an elevated risk of obesity development in children who are categorised in the highest group for TV viewing or having a TV set in the child's bedroom.

Findings from longitudinal studies have confirmed that TV viewing is an independent predictor of the change in the child's BMI, triceps, and sum of five skinfold measurments throughout childhood (Proctor et al., 2003) or positively associated with BMI at the adiposity rebound period (Jago et al., 2005). A systematic review based on 52 published studies of the role of media use, including TV, video games and computer use, with adiposity in youth, has concluded that the relationship between TV viewing and body fatness in children is small but statistically significant (Marshall et al., 2004). Furthermore, this association appears to be more profound in younger rather than older children (Must and Tybor, 2005).

Data on the role of physical activity and sedentary behavior patterns in promoting childhood obesity in Vietnam are limited. In a case control study investigating the risk factors for overweight in primary school children, it was observed that overweight children spent 20 minutes more per day on average on sedentary activity than did controls, where sedentary activity included TV viewing, studying, computer/video game playing (Loan et al., 2003a).

Recently, a cross-sectional study of an adolescent population in urban areas of HCMC found that children who watched TV more than 2 hours per day or who were insufficiently active, were at increased risk of being overweight. These effects become stronger after controlling for parental overweight, food consumption behavior, and socioeconomic factors (Hong, 2005).

There has been no study investigating the effect of physical activity patterns on obesity development in preschool children in HCMC.

2.3.3 Parental characteristics and familial environment

Although genetic factors contribute to familial patterns of adiposity, the genetic predisposition to gain fat is expressed when exposed to a particular environmental context (Bouchard and Perusse, 1988). In this section, parental characteristics and family environment are reviewed because obese parents provide both genes and obesogenic environments to their offspring (Cutting et al., 1999, Birch and Davison, 2001). As the socio-demographic factors belong to this group of variables, they too are reviewed.

2.3.3.1 Parental characteristics

Obese parents have been identified as being a strong predictor of obesity in their offspring, especially when both parents are obese (Whitaker et al., 1997, Zaimin et al., 2002, Danielzik et al., 2002, Danielzik et al., 2004, Treuth et al., 2003, Mamun et al., 2005, Reilly et al., 2005). A cross-sectional study of children aged 5 to 7 years in Northwest Germany reported the odds ratio (OR) for overweight in children increased with at least one overweight parent and that children's BMI was more closely associated with maternal BMI than with paternal BMI. For example, with only the mother overweight, the OR of being overweight in girls and boys is 3.1 and 2.9 respectively. There was a smaller effect for children with only their father overweight, that is, 2.4 and 1.8 for girls and boys respectively. The highest OR was found for children with both parents being obese, with the OR of 6.3 for girls and 7.6 for boys (Danielzik et al., 2002). These findings are in line with the results from the 1995 Australian National Nutrition Survey of children aged 7 to 15 years. Children who had overweight parents, especially overweight mothers, were more likely to develop overweight than those whose parents were of normal weight (Zaimin et al., 2002).

Furthermore, a two year follow-up study in 8 year old non-obese girls showed that girls with two obese parents had a significantly greater increase in fat mass compared with those who had two lean parents (Treuth et al., 2003). The impact of obese parents on their offspring has been demonstrated by a recent longitudinal study. The change in weight status from normal at 5 years of age, to overweight at 14 years of age, was observed in children who had at least one parent overweight or obese, and the transition had taken place more strongly in those with both parents overweight or obese (Mamun et al., 2005). Similar findings have been reported in the Avon prospective study of children from birth to 7 years of age. Both parents being obese resulted in an elevated risk of having obese offspring with an adjusted OR of 10.4 (Reilly et al., 2005).

Recently, several reports have stressed the importance of genes on development of obesity. A review based on a large number of family, twin and adoption studies, has concluded that there is a strong genetic contribution to variation of body fatness and development of obesity (Bell et al., 2005). Studies testing the hypothesis of assortative mating for obesity, have indicated the genetic contribution to the obesity epidemic by increasing the risk in subsequent generations. For example, two obese parents pass on additive and non-additive genetic factors predisposing to obesity in their offspring and this may explain an increase of an extreme form of obesity (Hebebrand et al., 2000). Furthermore, biologic inheritance is a requirement for the transfer of obesity risk across generations, as parent concordance for obesity is associated with a 20-fold higher obesity risk for offspring, compared with children of concordantly nonobese parents (Jacobson et al., 2007).

2.3.3.2 Familial environment

Growing up in an obesity-promoting environment also elevates the risk of becoming obese in childhood. Children from an obese or overweight family are noted to have a higher preference for fatty foods, a lower preference for vegetables and exhibited aspects of a disinhibited eating style (Wardle et al., 2001). In comparison with girls from non-obesogenic families, girls from obesogenic families have a diet higher in percentage fat. They also have a higher level of television viewing. They experience greater increases in BMI and BMI z-score from ages 5 to 7 years of age that persists across ages 7 to 11 years (Davison et al., 2005).

Children living in an obesogenic family are also characterised as having sedentary behavior and low physical activity levels. Data examining the correlation of environmental and parent-child interaction with physical activity in a group of 222 preschoolers, has shown a significant association between parental obesity and low levels of physical activity in their offspring (Klesges et al., 1990). Furthermore, parental physical activity level has been found to correlate with children's activity level. For example, using Caltrac accelerometers to measure physical activity in children aged 4 to 7 years and both parents, children living with parents who were both active were six times more likely to be active than children from a family with neither parent active (more effect for boys than for girls, with the relative odd ratios of 7.2 and 4.5 respectively) (Moore et al., 1991). In terms of parental support of children's physical activity, most studies have shown that encouragement, involvement and facilitation from parents can directly or indirectly predict a child's physical activity level and this effect tends to be more pronounced in young children

(Gustafson and Rhodes, 2006). Clearly, the family environment plays an important role in shaping eating and physical activity behavior in children.

In broader aspects of child development and health outcomes, the quality of the home environment in terms of stimulation and support patterns, has been considered to be strongly connected to a child's trajectory of growth (Bradley et al., 1996). The full HOME is a fully validated assessment instrument, which aims to identify and describe the homes of young children who were at significant developmental risk (Bradley et al., 1996). This instrument has been widely used to measure the quality and quantity of the home environment in relation to children's physical, social, and intellectual development (Bradley et al., 1996).

An abbreviated version of the full HOME assessment (HOME-SF) was used in a six year cohort study in the United States which reported that the HOME-SF cognitive scores and household income were significant predictors of childhood obesity (Strauss and Knight, 1999). Compared with children who have the highest HOME-cognitive scores, those who were from medium and low HOME-cognitive scores groups were at increased risk of being obese with OR: 2.32 (1.39-3.88) and 2.64 (1.48-4.70) respectively (Strauss and Knight, 1999).

There are conflicting findings from studies conducted in developed and developing countries of the influence of socioeconomic status (SES) factors, such as household income, parental education level and occupation, in predicting the development of obesity in children. A large number of studies carried out in developed countries have reported that children from low income households and families with lower levels of parental education were at an elevated risk of becoming obese compared with those from a higher income households and families with higher levels of parental education (Zaimin et al., 2002, Danielzik et al., 2004, Stamatakis et al., 2005, Lamerz et al., 2005). In contrast, household economic status was positively associated with the development of obesity in children in developing countries (Sakamoto et al., 2001, Luo and Hu, 2002, Hong, 2005, Ming, 2006).

Differing results from the two settings suggest different SES mechanisms influence childhood obesity between developed and developing countries. For example, low SES has been observed to be associated with unhealthy diet including greater consumption of high energy foods and lower consumption of fruit and vegetables in developed countries (Xie et al., 2003, Merchant et al., 2007). In addition, children raised in poor families were more likely to engage in sedentary behavior, such as spending more time on TV viewing, video-game use (Garemo et al., 2007) as well as a reduced access to facilities for recreational physical activity (Gordon-Larsen et al., 2006).

In developing countries, the shift towards a diet higher in fat and meat and lower in carbohydrate and fiber, as well as lower physical activity levels, has been observed to be associated with a higher SES adult population during the last decade (Popkin, 1994). A recent study examining the dietary intake of adolescents in China has shown children from wealthier families tend to consume higher amounts of meat, snacks, protein, fat, and cholesterol (Ming, 2006). Furthermore, the fat content in diet increases greatly and more rapidly with increased income (Ming, 2006).

Several cross-sectional studies have reported a link between parental overweight (BMI ≥ 23 kg/m^2) and overweight status in preschool children in Vietnam (Hung et al., 2003, Loan et al., 2003a). However, a lack of adjustment for confounders such as SES (Hung et al., 2003) or the use of simple analytic techniques such as bivariate tests, may limit the interpretation of these findings (Loan et al., 2003a). In addition, there has been no study examining the role of family environment in developing obesity in preschool children in Vietnam. It is therefore important to understand the influence of various aspects of the family on obesity in young children in Ho Chi Minh City.

2.3.4 School and community environmental factors

The environment outside the family context, such as school and community environments, may also have an affect on weight status of children through contributions to shaping dietary habits and physical activity behaviour (Kohl and Hobbs, 1998, St-Onge et al., 2003).

It has been suggested that the preschool setting has an affect on children's food preference by providing opportunities for expanding the availability and accessibility of foods (Birch and Fisher, 1998). A small study investigating the school context and the social influence of peers on preschoolers' food preferences, has found that children who were given opportuniti during meals to observe other children who do not like choosing and eating vegetables, has increased their preferences for not eating vegetables. Furthermore, young children are more affected by peer modeling than older children (Birch, 1980). Preschool attendance has been reported to be associated with a decreased risk of being overweight in six to 12 year old children compared with those who did not attend preschool in a longitudinal study of children aged three to five years (Lumeng et al., 2005). A possible explanation suggested that the structure of physical activity and different feeding patterns may account for this (Lumeng et al., 2005).

Like its influence on diet, preschool may provide a play environment with groups of children and their peers that have a strong influence on physical activity behaviour. Furthermore, the timing for such influence appears to be crucial, more so for young children than for adolescents (Kohl and Hobbs, 1998). In a cross-sectional study assessing the effect of the preschool setting on physical activity level in young children, the authors found that children participated in more moderate to vigorous activities (Dowda et al., 2004). Similarly, characteristics of the school have been proposed as having a much greater influence on a child's activity level than do the child's personal demographic characteristics (Pate et al., 2004).

The evidence regarding the effect of the neighbourhood environment on obesity-related eating and physical activity behaviours in children is growing. The perceived lack of safety of residential areas has been identified to be positively associated with sedentary activity such as TV viewing (Burdette and Whitaker, 2005). In addition, children aged five to six years whose parents believed that there was heavy traffic and limited public transportation in their area, were less likely to have outdoor activities such as walking and cycling (Timperio et al., 2004). In terms of overweight or obesity, researchers have reported an increased risk of being overweight or obese in children who live in poorer physical and less safe areas (Timperio et al., 2005, Lumeng et al., 2006).

The neighbourhood environment has been proposed as being responsible for changes in children's eating habits towards energy-dense food consumption. Trends in fast food restaurant use and snacking habits of children were reported to have increased over the last two decades and this is associated with the availability and accessibility of fast food outlets or convenience foods (St-Onge et al., 2003). However, older children appear to be more affected than younger children (Burdette and Whitaker, 2004, Sallis and Glanz, 2006)

In Asian countries, there is little evidence about the role of the community environment, on eating habits or the development of childhood obesity. The frequency of children aged two to six years eating dinner in restaurants in urban Beijing, China, was found to significantly correlate with the frequency of restaurant use by parents, but this eating behaviour was not related to the risk of overweight in children (Jiang et al., 2006). Another study conducted on Chinese adolescents has shown a decreased risk of being overweight with the presence of fast food restaurants in the residential area. However, this effect disappeared after adjusting for other risk factors (Ming, 2006).

There has been no study investigating the effect of nutrition in the community environment on eating habits and overweight in preschool children in HCMC. There has been one study conducted on adolescents (Hong, 2005).

In summary, there are multiple levels of determinants influencing the development of obesity in children including individual characteristics, family context, school and community environments. Since the relationships between these groups of variables is integrated and they interact with each other, an hierarchical, conceptual framework of risk factors for development of obesity in children is important to guide the design and analysis of studies assessing risk factors for childhood obesity (Victora et al., 1997).

2.4 Measurements in studies of childhood obesity

2.4.1 Assessment of adiposity in preschool children

Obesity is defined as an excess of body fat to the extent that it may result in a number of related health consequences (WHO, 2000). The most important criterion of obesity assessment, therefore, is a measurement of the amount of adipose tissue (WHO, 2000). There are numerous methods available to measure body composition in children varying in precision, from simple to more complicated. The choice of method should be based on whether the research is to be conducted in the laboratory or in clinical or community settings and keeping in the practicality and feasibility of the method in a given setting (Dympna and Mi-Yeon, 2003).

Dual-energy X-ray absorptiometry (DXA), and underwater weighing or densitometry using multi-component models are considered to be the reference methods. However, they are more suitable for use in a laboratory or clinical settings rather than in community settings, due to the cost and techncial challenges they entail (Jana and Andrew, 2001b, Angelo and Luciano, 2005). Simple anthropometry measurement including skinfold thickness, weight for height, body mass index (BMI) or circumference measurements are preferred for use as an approximation to the measurement of adipose tissue in large scale epidemiological studies (Michael et al., 1996, Sarria et al., 1998, Dezenberg et al., 1999, Pecoraro et al., 2003). The advantages of anthropometric methods are that they are simple, safe, and inexpensive to obtain, making them ideal for use in field settings.

Skinfold thickness measurement is probably the most widely used method to measure body composition in large scale epidemiological studies and is an acceptable method for assessing fat mass in a paediatric population. This technique measures the thickness of the subcutaneous fat layer directly, and therefore represents a seemingly attractive way to assess body fat (Willett, 1998, Sarria et al., 1998, Tennefors and Forsum, 2004, Angelo and Luciano, 2005).

In children, the most common skinfold thickness measurements are taken at the triceps, the subscapular, the suprailiac, and thee biceps sites (Jana and Andrew, 2001b, Angelo and Luciano, 2005). Use of multiple skinfold thickness nmeasurements is believed to give more reliable results about body fat, as the subcutaneous fat layer can vary substantially in the cross-section of the body surface (Willett, 1998a, Jana and Andrew, 2001b).

Using regression equations and theoretical assumption such as constancy of the composition of lean mass for a given age and gender, a number of prediction equations for the percent fat or body density in children from skinfold measurtments have been developed and validated against underwater weighing, and DXA. These prediction equations have been summarised in Table 2-2 (Slaughter et al., 1988, Weststrate et al., 1989). Few equations has been developed and validated for assessing body fat in children in Asia (Saijuddin and Dilip, 2004). Validating several equations derived for Caucasian children from skinfold thickness measurements in Chinese children aged seven to17 years, has shown that they are generally valid for use in this population (Deurenberg and Wang, 1997).

Table 2-3 Prediction equations for estimating body composition in children

Sources Subjects – n (age) Reference method	Equations/Models	Ethnic
Slaughter et al 1988 310 (8-29 yr) Underwater weighing	For white boys: % body fat = 1.21x(triceps + subscapular) – 0.008x(triceps + subscapular)2 – 1.7 For black boys: % body fat = 1.21 x (triceps + subscapular) – 0.008 x (triceps + subscapular)2 – 3.2 For all girls: % body fat = 1.33 x (triceps + subscapular) – 0.013 x (triceps + subscapular)2 – 2.5 For all boys if sum of the triceps and subscapular measurements are >35 mm % body fat = 0.783 x (triceps + subscapular) + 1.6 For all girls if sum of the triceps and subscapular measurements are >35mm % body fat = 0.546 x (triceps + subscapular) + 9.7	Caucasian and African American children
Deurenberge et al 1990 307 (7-20 yr) Underwater weighing	For prepubertal boys: Body density = - 0.0564 x logtwo skinfolds[a] + 1.8 x age x 10^{-3} + 1.0963 Body density = - 0.056 x logfour skinfolds[b] + 1.7 x age x 10^{-3} + 1.1133 For prepubertal girls: Body density = - 0.0633 x logtwo skinfolds[a] + 2.2 x age x 10^{-3} + 1.0984 Body density = - 0.0633 x logfour skinfolds[b] + 1.9 x age x 10^{-3} + 1.1187	Dutch children
Michael et al, 1996 98 (4-10 yr) DEXA	Fat mass = 0.23 x subscapular + 0.18 x weight + 0.13 x triceps - 3.0 kg)	White children
Sarria et al 175 boys (7-16.9 yr) Underwater weighing	Body density = - 0.0633 x log∑ skinfolds[c] + 1.1417 Body density = - 0.0035 x BMI + 0.001 x triceps + 1.121	Spanish children
Dezenberg et al 1999 202 (4-10 yr) DEXA	Fat mass = 0.56 x body weight – 8.17 Fat mass = 0.38 x body weight + (0.30 x triceps) + (0.87 x gender) + (0.81 x ethnicity) – 9.42	Caucasian and African American children
Saijuddin and Dilip, 2004 180 (1-5 yr) Validated equation based on height, weight and BIA	Boys: %fat = 5.304 + 0.269 x triceps + 0.50 x subscapular + 0.685 x midarm + 0.063 x age in month Girls: %fat = 7.017 + 0.053 x triceps + 0.201 x subscapular + 0.765 x midarm + 0.052 x age in month	Indian children

Although prediction equations are considered to be an acceptable method for estimating body fat in children, the accuracy of these body fat predictions is often poor (limits of agreement, ± 9% fat) and varies in relation to body fatness. Therefore, using this technique for longitudinal comparison may not be suitable (Wells and Fewtrell, 2006). Furthermore, the accurate raw values of skinfold thickness measurements may be confounded in prediction equations since an estimate of body fat with standard error was provided from these equations. It is therefore considered better to use the raw values rather than converting them to an estimate of total fat mass using prediction equations, especially for longitudinal evaluations (Wells and Fewtrell, 2006).

The skinfold thickness measurements taken at different sites are found to correlate differently with total body fat and the percentage body fat (%BF). The triceps site has been found to have a better correlation with %BF or body fat mass in children and women from 6 to 49 years (Roche et al., 1981) and children 4 to 10 years (Michael et al., 1996), while subscapular skinfold thickness highly was correlated with total body fat mass in boys 6 to 13 years (Roche et al., 1981). Similarly, the triceps site followed closely by the suprailiac and subcapular sites, had the strongest associations with percent body fat in obese children while suprailiac, subscapular, biceps, and triceps sites were the most useful, in that order, for normal-weight children (Jana and Andrew, 2001b). The sum of triceps and subscapular measurements also shows the best relationship with percentage body fat for normal weight children, whereas triceps plus suprailiac measurements strongly correlate with the percent body fat in obese children (Jana and Andrew, 2001b).

However, a number of problems related to skinfold thickness measurement technique have been raised for consideration when this technique is used to assess body fat content in children. Firstly, is the lower reproducibility of this approach, and the site of measurement and manner in which the skinfolds are measured, are sources of inter-observer variation (Willett, 1998a). In addition, intra-observer and inter-observer error becomes poorer in obese children, and as such, prediction equations underestimate the percent body fat in fatter subjects (Weststrate et al., 1989, Eisenmann et al., 2004, Wells and Fewtrell, 2006). It has been suggested that skinfold thickness cannot be used to estimate percentage body fat if the sum of skinfold thicknesses of biceps, triceps, suprailiac, and subscapular exceeds 120-140 mm (Weststrate et al., 1989, Sarria et al., 1998).

For this study, the individual skinfold thickness measurements at triceps, subscapular, and suprailiac sites and the sum of these measurements will be employed as indicators of subcutaneous fatness. They will be collected six months apart during the one year of follow-up.

Waist circumference is considered to provide a simple measure of central fatness, which may be more predictive of adverse outcomes such as lipid profile than total fat (Wells and Fewtrell, 2006). This measure was found to be strongly correlated with intra-abdominal fat measured with computerised tomography and abdominal fat measured by DXA (Goran et al., 1998). Other studies have reported the link between abdominal fat in children measured by waist circumference and cardiovascular disease risk factors (Freedman et al., 1999, Maffeis et al., 2001). However, this method is known to have limitations in distinguishing between the intra-abdominal and subcutaneous fat (Willett, 1998). Hence, it is considered to be not as accurate as a measure of internal visceral fat (Wells and Fewtrell, 2006). Since the level of health risk associated with a particular waist circumference is proposed to vary by sex and across populations, the development of sex- and ethnic- specific cutoffs is recommended (Gibson, 2005a). At present, national reference data for waist circumference for Vietnamese children is not available. Furthermore, the relationship between central fat indicated by waist circumference with adverse health outcomes is rarely investigated. This suggests future studies on the ability of waist circumference in classifying central fatness for Vietnamese children are needed.

2.4.2 Assessment of obesity in preschool children

2.4.2.1 Weight for height

Weight for height is an index reflecting body weight relative to height and is recommended by WHO for use in evaluating both under and over-nutrition in children under 10 years of age (WHO, 1995). One of the advantages of employing this indicator is that a knowledge of the child's age is not required-a factor that might be difficult to assess in less developed areas (WHO, 2000). Based on a standard reference population, overweight is statistically defined as weight for height above +2 standard deviation (SD) relative to the reference median (WHO, 1995). This indicator is thought to be adequate for assessing obesity in population based surveys because of majority of individuals with high weight-for-height are obese (WHO, 1995). Also, it has been noted that the classification of overweight or non-overweight using this criteria is based mainly on statistical convenience rather than a known health risk (Lobstein et al., 2004).

The earlier growth standards recommended for international use were from a population studied by the US National Centre for Health Statistics (NCHS/WHO), in which early childhood growth was not adequately represented. Therefore a multinational growth reference was developed – WHO Child Growth Standards. The population reference in the new WHO standards was developed based on groups of healthy children from a diverse set of countries including Brazil, Ghana, India, Norway, Oman, and the USA. These children were raised under optimal environments that were likely to favour achievement to their full genetic growth potential. Furthermore, their mothers engaged in fundamental health-promoting practices such as breastfeeding and not-smoking. This population is therefore considered to meet the criteria for an internationally applicable standard of growth and development for children younger than five years of age. By using the least mean square (LMS) method to construct the growth curves, the new WHO standards are considered to address skewed data adequately and to generate fitted curves following the empirical data closely. Three commonly used anthropometric indices - length/height for age, weight for age, and weight for height, - as well as BMI for age were provided from the new standard (WHO, 2006).

Because of notable difference varying by age, sex, anthropometric measure, and specific percentile or z-score curve, there are differences in prevalence estimates of under-nutrition and overweight in children between the new WHO standard and the NCHS/WHO reference, especially in infancy. The stunting (low height for age) will be greater throughout childhood by using the new WHO standard, compared with the previous international reference. Similarly, there will be a substantial increase in underweight rates during the first half of infancy (0-6 months) and a decrease thereafter. With regard to wasting, the estimate will be substantially higher with the new WHO standard during infancy. Using the new WHO standard to classify overweight, it is noted that a greater prevalence of overweight varying by age, sex and nutritional status of the index population is produced (WHO, 2006).

Nevertheless, there has been no clear recommendation from WHO on the cutoffs points for weight-for-length/height and BMI to define overweight in children using the new WHO standard. It has been know that the cutoffs of +2 SD for defining of overweight using the previous international reference was based on statistical convenience, that facilitated clinical screening and population-based surveillance (WHO, 1995). Due to the lack of a clear recommendation for defining overweight in children under five years of age using the new standard, this study employs the cutoffs of +2 SD and +3 SD for classifying overweight and obesity respectively based on the new WHO standard (WHO, 2006).

2.4.2.2 Body Mass Index (BMI)

Among indices derived from anthropometry to define obesity, BMI is the most commonly used for assessing childhood obesity in both clinical and population-based studies (Bellizzi and Dietz, 1999, Lobstein et al., 2004). BMI is a measure of weight adjusted for height and calculated by weight in kilograms divided by the squared height in meters. Although there are a number of drawbacks in using this indicator as a proxy of adiposity in children, it is strongly recommended for use to classify obesity in children and adolescents because of its feasibility, high reliability and acceptable validity (Troiano and Flegal, 1998, Bellizzi and Dietz, 1999, Hall and Cole, 2006, Reilly, 2006a).

This index is considered to have high reproducibility because of the high reliability of weight and height measurements; therefore, it can be used to compare adiposity within and between populations (Troiano and Flegal, 1998, Bellizzi and Dietz, 1999). Findings from validation studies of BMI as a measure of body fatness in children against underwater weighing, DXA, and BIA have all shown a moderate to high correlation (Angelo et al., 1998, Robert and Peter, 1999, Mei et al., 2002). Studies on the ability of BMI to classify obesity, have demonstrated a high specificity and low to moderate sensitivity in children (Ross et al., 1996, Mast et al., 1998, Robert and Peter, 1999, Reilly et al., 2000). High specificity is considered to be an advantage of BMI for screening obesity in clinical settings, when few non-obese children are assessed as obese. The potential psychological and physical harm of misclassifying and treating children who are not obese is minimised (Hall and Cole, 2006, Reilly, 2006a). Low sensitivity of BMI in classifying obesity is a major concern for use in public health settings; however, the choice of appropriate cut off points may improve the performance of BMI in screening obesity in children (Ross et al., 1996, David et al., 2005, Reilly, 2006a).

Although experts have recommended using BMI as a proxy measure of adiposity in research on childhood obesity, there are a number of related issues that need to be considered when applying this indicator (Ross et al., 1996, David et al., 2005, Reilly, 2006a). In children, BMI is a measure of excess weight relative to height rather than excess of body fat content which varies with age, gender, and ethnicity as well as maturation status, unlike in adults who have reached their peak height and adiposity gain dominates (Troiano and Flegal, 1998).

It is known that BMI dramatically changes during childhood and adolescence, increasing rapidly during the first year and diminishing until approximately five to six years of age before a gradual growth of body fat through adolescence and adulthood (Rolland-Cachera et al., 1984). At the same BMI level, girls have more fat content than boys (David et al., 2005). Furthermore, during growth and maturation, the body proportion, bone mass, the ratio of lean to fat mass changes at different times and rates (Troiano and Flegal, 1998). Therefore, BMI levels of children and adolescents should be compared with a reference standard according to age and gender.

The comparison of BMI with a reference population provides a measure of BMI Z-score as another assessment of obesity in children. However, BMI for age Z-score requires suitable statistical programming skills. In addition, the importance of selecting a reference population and arbitrary cutoffs point in classifying overweight or obesity are considered to be limitations for the use of this indicator (Lobstein et al., 2004).

The relationship between BMI and body fat also reflects ethnic differences (Neovius et al., 2004). At the same BMI level and age, black children have less body fat content than children of European descent, while Asian children have more body fat content (David et al., 2005). This is considered to be a problem in creating a universal classification system for comparison of children from different ethnic groups (Neovius et al., 2004).

The ability of BMI in assessing adiposity also changes with the level of body fatness. Higher correlation between BMI and body fatness was found in obese children compared with lean children (David et al., 2005). Therefore, the accuracy of BMI as an indicator of adiposity varies with age, gender, ethnicity and the degree of body fatness (David et al., 2005).

As the adverse health outcomes from excess fat are rarer in children than in adults, statistical approaches are used in BMI classification systems to define obesity in children (Troiano and Flegal, 1998, Neovius et al., 2004, Lobstein et al., 2004). Based on a reference population according to age and gender, overweight and obesity are defined if BMI is above an arbitrarily selected percentile which may or may not be related to increased health risks (Troiano and Flegal, 1998, Neovius et al., 2004). For example, to determine overweight and obesity, the 2000 Centre for Disease Control and Prevention (CDC) growth chart has used age and gender- specific 85th and 95th centiles while in the UK the definitions have used the 91st and 99th centiles of the British reference (Neovius et al., 2004). Other nations have different percentile cut off points to classify obesity; Belgium and Netherlands chose 97th percentile, whereas, Finland, Greece and France have employed a 90th percentile, and Australia an 85th percentile (Neovius et al., 2004). To ensure there was a valid method to assess the global prevalence and make international comparisons of the prevalence of obesity in children and adolescents, the International obesity Task Force (IOTF) has proposed a universal classification system. This system has created age and gender specific cut off points for children and adolescents based on the percentile (or z score curve) of a new child BMI growth reference that pass through the BMI adult cut off points of 25 and 30 kg/m^2 for overweight and obesity respectively at the age of 18 years (Cole et al., 2000). This method assumes that these adult cut offs represent increased risks for children. The reference population used to develop IOTF criteria is based on the nationally representative datasets from six nations including Brazil, Great Britain, the Netherlands, Hong Kong, Singapore, and the United States. Except for the data from Singapore with children aged more than six years, the other five national data included children from birth or two years of age to adult, particularly Hong Kong data set (from birth to eighteen years). Thus, this reference population includes the age group that is close to the age of children in this study, suggesting it can be used to classify overweight and obesity in this child population.

There are a number of arguments about whether and under what circumstance the national or international BMI classification system is more appropriate for use. For the BMI distribution-based system, in addition to arbitrary choice of cut off points not chosen on the basis of health risk, any potential updated standard based on new data is supposed to omit the capacity of monitoring secular trends as BMI status in populations changes over time (Neovius et al., 2004). Recently, the 2000 CDC growth chart has been widely used in assessing obesity in other nations such as Canada, Chile, Mexico, and Argentina. However, this system may have some limitations for use outside the Americans, due to genetic and environmental differences (Neovius et al., 2004).

With respect to the IOTF system, there is concern about the representativeness of the reference data for global use since it was constructed using reference data from five out of six nations that have moderate to high income status (Neovius et al., 2004). The selected age of 18 years at which the overweight and obesity centiles correspond to 25 and 30 kg/m^2, is also controversial because it may underestimate the prevalence of obesity in populations having an increasing trend in BMI from 18 years onwards, such as in the UK (Chinn and Rona, 2002, Reilly, 2006a). In comparison with national reference data for screening obesity, the IOTF criteria has been shown to have a lower sensitivity and to differ significantly for boys and girls (Reilly et al., 2000, Chinn and Rona, 2002). The underestimation of obesity with the IOTF definition compared with other definitions, such as the 2000 CDC growth reference or national references, has been reported in several studies (Kain et al., 2002, Patricia et al., 2004, Blanca et al., 2004, Enrico et al., 2006).

In terms of public health research, comparison and definitions of international and national data references can be made without problem, provided consistent cut-off points are used (Hall and Cole, 2006). However, various definitions used to identify a group of children with increased risk of obesity and its complications within a whole population, may affect guidelines or intervention programs, such as the advice given, the cost as well as the benefits or harm for individuals and communities (Hall and Cole, 2006).

Despite these limitations, the IOTF international classification system has been used worldwide to assess obesity in children and adolescents for a number of reasons. It is considered to give a more conservative view of the extent of overweight and obesity in children compared with the BMI distribution based systems because with the latter the prevalence of overweight and obesity is set to a fixed proportion for all ages of both genders (Lobstein et al., 2004). In addition, the IOTF system provides a definition of obesity in children that is consistent with that of adults by adopting the adult BMI cut off points of 25 and 30 kg/m^2 corresponding to about the 80^{th} and 90^{th} percentile of NCHS standard at age 18 years, and can be used through childhood and adolescence to classify overweight and obesity (Bellizzi and Dietz, 1999). Evidence of associations between obesity in children with increased illness risk is not well established. Research findings have shown strong tracking of BMI level of childhood into adulthood, providing a rationale for defining obesity in childhood based on adult health risks (Neovius et al., 2004). In summary the IOTF system is appropriate for use in monitoring the worldwide obesity epidemic in children and may be applied where national reference data are not available (Lobstein et al., 2004).

Although BMI is not a perfect tool for measuring adiposity in children, it is currently used worldwide to define obesity in children and adolescents and its use is strongly recommended by expert committees. Since there is no system for classification of obesity for children in Vietnam, the IOTF system to define overweight and obesity in children is used throughout this thesis. The new WHO Child growth standard has also been employed in assessing overweight status among children aged 4 to 5 years in this study in order to allow a comparison between the two classifications in defining childhood obesity.

2.4.3 Assessment of dietary intake of preschool children

As obesity is an ultimate consequence of a prolonged imbalance of energy intake and energy expenditure, measurements of these components are very important in studies of childhood obesity. Assessment of dietary intake helps researchers understand its importance in the development of obesity in children.

Studies of food habits and dietary intake are the most challenging aspects of obesity research, especially in children (Michael, 1998). Children tend to have diets that are highly variable from day to day and their food habits can change rapidly (Thompson and Byers, 1994). As young children have limited cognitive capacity to report their diets, for example, limited memory and knowledge of foods, the onus of dietary reporting falls to parents (Livingstone and Robson, 2000). However, evidence suggests that parents are only reliable reporters of their children's food intake for food eaten at home. When parents work away from home however, or children attend school, parents are less able to report what their child actually consumes. Thus, food intake measurement in young children is prone to bias introduced by the surrogate respondent (Livingstone and Robson, 2000).

Two groups of methods are used to assess diets of preschool-aged children: respondent-based methods, such as dietary recalls, dietary records, and food frequency questionnaires (FFQs); and investigator-based techniques such as direct observation and collection of duplicate portions, and physiologic intake, such as doubly labelled water, or biomarkers of dietary intake, such as serum carotenoids (Serdula et al., 2001). In this section three techniques are reviewed, including 24 hour recall, food record, and FFQs because of their suitability for population-based research.

In the 24 hour recall, parents or carers are asked by the trained nutritionist to recall the child's exact food intake during the previous 24 hour period or day preceding the interview. It permits estimates of absolute rather than relative intake of energy and other nutrients. Another strength of this method is that it does not require a high level of literacy, a concern in collecting diet information from a populations in developing countries (Willett, 1998b). The eating behaviour of respondents is less likely to be altered since the information is collected after the fact. Also, minimal burden is imposed on respondents compared to keeping food records.

A major limitation of this method is its reliance on memory, both for identification of foods eaten and for quantification of portion sizes as well as the need for a highly trained dietary interviewer. Because a single 24 hour recall is not sufficient to describe an individual's usual long-term intake of food and nutrients, multiple 24-hour recalls on the same individual over several days are required to assess usual long-term intake. This is considered to be a barrier in employing this technique in large-scale epidemiologic research. Correlations for energy and macronutrients of 0.45 or greater have been reported in most validation studies of 24 hour recall in assessing food intake of preschool children against various criteria methods including direct observation, food records, and duplicate portions. Difference in mean energy intake between 24 hour recall and criteria methods ranges from underestimating about 3% with doubly labelled water to a 15% overestimate with observed food intake, food records, and duplicate portions (Serdula et al., 2001). When doubly labelled water is used as a standard measure, multiple 24-hour recalls among children younger than 7 years have been shown to accurately reflect energy intake on a group basis but accuracy at the individual level is poor (Johnson et al., 1996, Reilly et al., 2001).

For the food record method, respondents are asked to weigh or measure and visually estimate the amount of food consumed and record the time the food is eaten. A detailed description of all foods and beverages (including brand names) as well as the method of preparation and cooking are recorded. With this method, reliance on respondent memory is minimised. Like the 24-hour recall method, data collected through this technique is informative and may be useful in assessing dietary change in nutrition intervention studies. However, similar to the 24-hour dietary recall method, the food record method requires a number of days of recording food intake in order to obtain an estimate of usual intake of an individual. Also, respondents should be motivated, numerate, and literate. Therefore, this method carries a higher respondent burden than do food recalls or FFQs. In addition, respondents may change their usual eating pattern to simplify the measuring or weighing or, alternatively, to impress the investigator (Willett, 1998b). There have been few validation studies of food records to measure dietary intake in preschool children. Available evidence has shown a moderate correlation for mean energy intake of 0.41 between food records and doubly labelled water and an underestimate within 7% compared with a validation standard such as doubly labelled water or diet history (Serdula et al., 2001).

Food frequency questionnaires (FFQs) are methods for measuring average long-term dietary intake (Willett, 1998b). Respondents are asked to report their usual frequency of consumption of each food from a list of foods, for a specific period. For preschoolers, the usual referent period is the past month to the past year. Because of the longer reference period, usual individual intake may be inferred from a single FFQ. Development of the food list is considered to be crucial to the success of the FFQ. A comprehensive food list enabling computation of the full range of nutrients rather than a finite list to determine the intake of a few nutrients is preferable in studies investigating aetiologies because it includes the ability to adjust for energy intake in order to fully examine the diet-disease relationship. To estimate relative or absolute nutrient intakes, FFQs incorporate portion size questions, or specify portion sizes as part of each question. With quantitative FFQs, portion size is collected for all foods, whereas this information is collected only for foods consumed in typical portion sizes (e.g. bread slices, milk glasses) on semi-quantitative FFQs and not collected on the non-quantitative FFQs. Using FFQs in assessment of dietary intake is known to impose less burden on the respondent than most of the other dietary assessment methods. Data from FFQs are easy to collect and process and can be used to rank individuals according to their usual consumption of food or nutrient intake. Using this method, subjects with low intakes can be discerned from those with high intakes. This permits the calculation of the effects of nutrient intake on disease, in studies of association between food intake and disease (Willett, 1998b).

For these reasons, FFQs have become the primary method of measuring dietary intake in epidemiological studies (Willett, 1998b). However, findings from validation studies of FFQs for measuring dietary habits of young children, have reported an overestimate of mean energy intake from FFQs. When compared with doubly labelled water, the FFQs overestimate mean energy intake by 59%. However, this study used adult portion sizes, which were 25% - 33% greater than the typical serving suggested for preschoolers (Kaskoun et al., 1994). Similar results have been reported when multiple 24-hour recalls are employed as a standard measure and the difference in energy intake between the two methods has varied in different validation studies from 0.2% (Blum et al., 1999) to 25% (Wilson and Lewis, 2004). Also, correlation coefficients for nutrient intakes measured by FFQs and by validation methods are low to moderate. After adjusting for both energy intake and the effect of intra-individual variability in intake, adjusted correlations are reported from 0.29 to 0.43 for protein and 0.35 to 0.62 for fat in validation studies performed in the USA (Stein et al., 1992, Blum et al., 1999).

In summary, FFQs are not designed to estimate the individual's usual intake of food. They are suited for ranking subjects according to food or nutrient intake, rather than for estimating the levels of intake. Therefore, the levels of nutrient intake measured by FFQs should best be regarded as only approximations (Thompson and Byers, 1994). In addition, since different FFQs perform in unpredictable ways in different populations, it is recommended an FFQ developed for one population should not be employed for another population unless dietary habits are very similar (Cade et al., 2002).

Compared to FFQs, food recalls and food records may provide a more accurate group mean estimate of energy and other nutrient intake. These techniques, however, require more effort for both researchers and respondents. In this study, the main concern is the relationship of the candidate risk factors and changes in adiposity over one year of follow-up, where dietary factors of interest are the food intake in the preceding three months. Repeated measurements of dietary intake were carried out at 6 month intervals over one year. For these reasons, the FFQ method was chosen for assessing food intake in children aged four to six years in this study. A validated FFQ for children aged six to 36 months in HCMC in 2003 was modified for use, to estimate the dietary intake of the studied children.

2.4.4 Assessment of physical activity in preschool children

Physical activity is defined as any bodily movement produced by skeletal muscle that results in energy expenditure (Caspersen et al., 1985). Low levels of physical activity in children have been identified as increasing the number of adverse health outcomes including childhood overweight (Trost et al., 2003, Eisenmann, 2004). Findings from research also confirm the health benefits of physical activity (Must and Tybor, 2005). Thus, assessment of physical activity is essential to understand how it affects overweight/obesity and also to develop a guide for an appropriate intervention strategy.

There are a number of methods used to estimate physical activity in children. Among these methods, direct observation, doubly labelled water and indirect calometry are considered to be criterion methods (Sirard and Pate, 2001). Due to the considerable effort needed from participants and researchers and the relatively high cost, they are difficult to apply in epidemiologic studies (Sirard and Pate, 2001). Other measurement tools, such as heart rate monitoring, pedometer, accelerometer and proxy questionnaires are more appropriate and often used for estimating physical activity in child populations in epidemiological studies (Trost, 2001, Sirard and Pate, 2001).

Heart rate monitors (HRMs) are commonly used in sports training. The principle of using this tool to assess physical activity is based on the linear relationship between heart rate and oxygen consumption. It therefore provides an estimate of energy expenditure and allows for the assessment of physical activity (Sirard and Pate, 2001). A number of factors may influence the accuracy of findings such as age, body size, emotional stress, physical fitness, and mode of exercise, especially low activity patterns. Furthermore, heart rate lags behind changes in movement and potentially masks a child’s intermittent activity patterns (Trost, 2001). On the other hand, this method appears to be valid for estimating energy expenditure and physical activity patterns in non-obese children (Sirard and Pate, 2001).

In comparison to HRMs, the use of accelerometers to monitor physical activity is proposed as providing a valid assessment of activity patterns in children varying from low to high activity, while HRMs measurements are robust only for high activity patterns. In addition, this method reduces participant burden compared with HRM use (Trost, 2001). These electronic devices capture acceleration produced by body movement from one to three dimensions and the information recorded allows for the assessment of frequency, intensity and duration of the movement (Trost, 2001). Both one-dimensional and three-dimensional accelerometers show comparable assessment of free-living physical activity in children, although the latter appears to be better in several validation studies of these two types of accelerometers (Trost, 2001).

The drawbacks of using this method for evaluating physical activity in children are its limited ability to assess cycling, locomotion on a gradient or activities with limited torso movement. Also, using a predictive equation for energy expenditure from accelerometer counts may provide inaccurate estimates because of additional measurement error (Trost, 2001, Sirard and Pate, 2001).

The use of pedometers, a simple type of motion sensor, is considered to be a good cost effective alternative to accelerometers and HRMs. They record total counts or steps over the observational period (Trost, 2001). The validation studies of this method against oxygen consumption and direct observation have shown moderate to high correlation in total volume of physical activity in children (Sirard and Pate, 2001, Bjornson, 2005). In addition to providing relative volume of activity, however, information on physical activity assessment from pedometers does not provide either the magnitude of detected movement or duration of physical activity (Trost, 2001). It is therefore suggested as a method of choice in studies aimed to document relative change in physical activity or to rank order groups of children on physical activity participation (Trost, 2001).

Among physical activity assessment methods, self-reporting is most commonly used to measure children's physical activity where proxy reports by parents/guardians and teachers are employed to assess physical activity (Sallis, 1991, Sallis and Saelens, 2000). The advantages of this method are its relatively low cost, the ability to collect a variety of physical activity variables over time, and in particular, the feasibility of measuring physical activity for a large number of children (Sallis, 1991). Furthermore, recalls do not alter the behaviour being studied, and activity behaviour patterns can be examined because it allows for assessment of all dimensions of physical activity (Sallis and Saelens, 2000). For these reasons, this measurement technique is suitable for large study populations, if a valid and reliable instrument can be developed (Trost, 2001).

Attempts have been made to develop reliable, valid proxy questionnaires by parents, teachers or a combination of parents and teachers for assessing physical activity in preschool children (Sallis, 1991, Sallis and Saelens, 2000, Kohl et al., 2000). However, it has been noted that there are few valid proxy-report instruments available for measuring physical activity in children (Kohl et al., 2000). The proxy questionnaires used in validation studies may be modified from existing questionnaire or developed to measure dimensions of a child's movements in terms of type, frequency, intensity and duration, based on proxy-reporter recall (Harro, 1997, Amanda et al., 2004). Others have employed the questionnaire with the aim of capturing usual activity patterns for grouping children into low or high movement categories using rating scales rather than specific recall of physical activity (Halverson and Waldrop, 1973, Manios et al., 1998, Chen et al., 2002, Janz et al., 2005). A number of validated questionnaires aimed to measure high intensity activity such as vigorous activity rather various intensity levels (Harro, 1997, Manios et al., 1998). Since there is growing evidence of the importance of sedentary behaviours and moderate physical activity on health outcomes, it has been suggested that all intensity levels should be assessed in measuring physical activity (Sallis and Saelens, 2000).

The choice of a criteria standard is considered to be critical in validation studies of proxy reports and one of five methods - monitoring, direct observation indirect calorimetry, doubly labelled water, or direct calorimetry - should be used to validate self-report methods (Kohl et al., 2000). Due to the feasibility of implementation compared with laboratory-based methods such as doubly labelled water, accelerometers and other motion sensors are becoming more commonly used as a criteria measure in validation studies of proxy reports for assessing physical activity in children (Kohl et al., 2000, Sallis and Saelens, 2000). Accelerometers have been shown to be acceptable in assessing the intensity of child physical activity (for 1 day, r = 0.42-0.47; for 6 days, r = 0.81-0.84) (Janz et al., 1995) and provide each minute of monitoring to be classified by intensity, therefore allowing for validation of the proxy-report frequency, intensity and duration (Sallis and Saelens, 2000). Nevertheless, some limitations of this technique have been identified. Firstly, accelerometers may underestimate physical activity because of their limited ability to assess cycling, locomotion on a gradient such as walking or running up hills, or aquatic activities such as swimming. In addition, due to the lack of consensus in the cut-off points applied to define intensity levels in young children, the application of laboratory-based contrived cut-off points is questionable for assessing less-structured activities typical of free-living conditions and may result in substantial error (Rennie et al., 2006). Most validation studies have employed correlation coefficients to test the validity of proxy report against criteria measure (Kohl et al., 2000). Percentage agreement and Kappa statistics have also been used in other studies (Kohl et al., 2000). The statistical approach chosen depends on the association between data collected from proxy reports and a criteria standard. Complete assessment of validity of a method should include multiple approaches rather than relying solely on correlation coefficients (Kohl et al., 2000).

Generally, findings from validation studies of proxy reports assessing physical activity in young children have provided some support for the use of this measurement instrument in obtaining activity information for children. Correlations between validated questionnaires with a criteria measure vary from non-significant to moderately strong, probably due to the quality of the questionnaires and the validation criteria used (Kohl et al., 2000). Table 2-4 lists a number of validation studies for proxy reports measuring child physical activity. Some studies have validated either parental or teacher proxy reporting while others have combined both. More than one criteria standard has been used in some studies.

In addition to the contribution of the quality of questionnaire and validation measurement on poor validity, a number of related factors also need to be addressed. As a child's physical activity is known to be spontaneous and sporadic, neither planned nor structured, as it is for adults, proxy reporters may be unable to capture and quantify all types of a child's free-play activities (Sallis and Saelens, 2000). Also perceptions and environmental factors such as socioeconomic status of proxy reporters, have influenced the accuracy of the collected information (Sallis and Saelens, 2000, Amanda et al., 2004). Another issue of self-report is bias, such as over and under-reporting (Sallis and Saelens, 2000). For example, parents and teachers have estimated a higher intensity for girls aged 7 to 8 years than what actually occurred in a validation study of a questionnaire to assess physical activity of young children (Harro, 1997). Conversion of the qualitative information into quantitative data such as duration or categorizing intensity of physical activity, has been suggested as another limitation of measuring physical activity by self-reporting (Sallis and Saelens, 2000, Amanda et al., 2004).

There have been few attempts to validate proxy questionnaire assessing physical activity in children in Asian countries. Several studies examining the importance of physical activity on obesity in adolescents in Vietnam and China have employed a physical activity recall questionnaire validated for Australian adolescents (Hong, 2005, Ming, 2006).

A physical activity proxy questionnaire developed for assessing physical activity in preschool children in the US (Metallinos-Katsaras et al., 2000) was modified to measure physical activity in children participating in this study. A small subsample was used to validate this proxy report against a uni-axial accelerometer, chosen as criteria measure.

Table 2-4 Validation of proxy reports to assess physical activity in young children

Study	Participants	Instrument	Time frame	Criterion measure	Validity
Halverson and Waldrop, 1973	33 boys, 25 girls; mean age = 2.5 years	Teacher ratings of activity	1-day	Activity recorder	r = 0.41-0.66
Noland et al., 1990	21 girls and boys; mean age = 4.25	Parental and teacher rating	1-day	20 minute video in school setting	r = -0.19-0.66
				6 hours of direct observation in home setting	r = -0.13-0.04
Harro, 1997	30 boys, 32 girls; mean age = 7.0	Parental report Teacher report	4-day	Heart rate	r = 0.40
				Caltrac	r = 0.53
Manios et al, 1998	17 boys, 22 girls; 6 years	Parental report	3-day	Heart rate	Spearman = 0.72-0.82
		Teacher report	5-day		Spearman = 0.07-0.59
Chen et al, 2002	12 boys, 9 girls; 3-4 years	Teacher ratings of activity	3-day	Actiwatch	Mean counts for children rated high PA level was significantly higher than for those rated low PA level, p < 0.05
Amanda et al, 2004	58 boys and girls, mean age = 5.3 years	Parental report	7-day	MTI	Spearman = -0.06-0.05
Janz et al, 2005	91 boys, 113 girls, mean age = 5.7 years	Parental ratings of activity preference	4-day	MTI	Spearman = 0.33-0.36

2.5 Summary

In summary, this literature review has highlighted the magnitude and increasing trend in childhood obesity in the developing world. This epidemic is now comparable to that which took place in the developed world over the last few decades, but it is a more complex situation involving co-exisitng over- and under-nutrition and related health consequences. Because of the short and long-term effects of childhood obesity on health outcomes and associated health economic costs, there is an urgent need to take action and halt this epidemic. It is important to understand the root of the development of obesity in young children in developing countries in order to develop evidence-based intervention programs.

Research findings have indicated that the causation of obesity in children is complicated, with multiple levels of factors involved. At the present, studies on aetiology of childhood obesity in Vietnam are still sparse. Almost all studies on nutritional status of preschool aged children in Ho Chi Minh City have been cross-sectional in design and therefore cannot provide cause and effect conclusions about factors related to obesity in the children studied. Furthermore, the lack of validated instruments in measuring food intake and physical activity has limited the capacity of studying the causes of obesity development in this young child population over last years. Additionally, inadequate attention on monitoring the trends in overweight and obesity in young children may result in delayed actions to this epidemic. For these reasons, it is time to perform a study to comprehensively understand the development of childhood obesity in Vietnam. One of methods recommended for studying of predictors is employing an hierarchical, conceptual framework with consideration of contextual and individual level factors. Based on this conceptual framework, a one year follow up study was conducted which aimed to establish the cause-effect relationship between potential predictors and the development of obesity in terms of changes in adiposity indicators such as BMI, skinfold thickness as well as overweight and obesity prevalence, in preschool aged children in urban areas of Ho Chi Minh City. In addition, the magnitude and trends in overweight and obesity as well as dietary and physical activity patterns among this population were examined.

Chapter 3 Methodology

3.1 Longitudinal study

3.1.1 Study design

A one-year follow-up study was conducted from March, 2005 to March, 2006. The study aimed to identify the risk factors, including lifestyle factors (dietary intake, physical activity) and environment factors at preschool, neighbourhood and home environment, associated with the relative changes in indicators of adiposity (BMI, skinfold thickness), in a representative sample of children aged 4 to 5 years living in urban areas of HCMC.

3.1.2 Study population and setting

The reference population for this study are preschool children aged 4 to 5 years of both genders living in urban areas of southern provinces and cities in Vietnam. The source population are preschool children aged 4 to 5 years attending urban kindergartens of HCMC, Vietnam. This is the largest and most economically developed city in Vietnam. The administrative structure of the city consists of four levels with districts, wards, quarters and hamlets. Across the city, there are twenty two districts with twelve districts in urban areas and eight districts in sub-urban areas. Among urban areas, there are four wealthy and eight less wealthy districts. The attendance of young children in kindergartens in urban areas of HCMC is high, with two thirds of the urban districts having more than 90% of children aged 4 to 5 years enrolled. The remaining districts have from 56% to 80% of children aged 4 to 5 years enrolled (Table 3-1) (Department of Education, 2005). This high rate of participation in kindergarten allowed the study to be carried out in kindergartens without major selection bias of the studied population. In the districts from which the sample was drawn for this study, the rate kindergarten attendance ranged from 80 to 100%. The urban areas of HCMC have 266 kindergartens with total 37,287 children aged 4 to 5 years enrolled, with 10,732 children coming from wealthy areas (Department of Education, 2005).

Table 3-1 Rate of kindergarten participation in children aged 4 to 5 years (born in year 2000) in urban districts in HCMC in 2005

Locations	Districts	The number of kindergartens	Children born in year 2000 attending kindergartens in urban areas of HCMC N(%)	Districts sampled
Wealthy districts	Dist 1	20	2313 (92)	X
	Dist 3	30	2605 (100)	X
	Dist 5	24	3246 (79)	X
	Dist 10	23	2568 (96)	X
Less wealthy districts	Dist 6	22	2770 (95)	X
	Dist 11	23	2520 (80)	X
	Binh Thanh	32	4523 (91)	X
	Tan Binh	20	4689 (89)	X
	Dist 4	15	1631 (56)	
	Dist 8	17	3127 (75)	
	Phu Nhuan	14	1981 (100)	
	Go Vap	26	5314 (94)	

3.1.3 Sample size

It has been suggested that BMI itself is considered to be the better alternative in assessing adiposity change when following children at risk of obesity, compared with BMI Z-score (Cole et al., 2005).The economic level of the community was found to be a risk factors for being overweight or obese in this child population in the 2002 study (Hung et al., 2003). It is therefore hypothesised that whether children from area higher economic status experienced significant changes in BMI over the one year period of study, compared with those who were from areas having lower economic status.

The main outcome of this longitudinal study was the average change in BMI of children aged 4 to 5 years, between wealthy and less wealthy groups over one year of follow up. Thus, a sample size was calculated using the formula for comparing two means:

$$n = \frac{2\sigma^2}{\Delta^2}\left(Z_\alpha + Z_\beta\right)^2$$

where:

σ = standard deviation within group

Δ = difference in means of size

Z_α = cut off value of the standard normal distribution for probability of alpha for a two sided test

Z_β = cut off value of the standard normal distribution for probability of beta in the upper tail

A cross-sectional study conducted in 2002 on the nutritional status of children in kindergarten in HCMC, provided information about the difference in BMI of children aged 4 to 5 years of age from wealthy urban districts compared with children from less wealthy urban districts (Hung et al., 2003). Therefore, the sample size was estimated using this average difference in BMI change of 0.8 kg/m^2. Assuming a standard deviation of 2, a significance level of 5%, and power of 80%, the sample size in each group was estimated to be 99 children. This sample size estimate needed to be adjusted for the effects of the clustering. The design effect was calculated as 2.5 based on the data on the nutritional status of preschool children in HCMC collected in 2002. Thus, the required sample size was 248 for each stratum of wealthy and less wealthy urban districts. The total sample size was rounded to 500 children aged 4 to 5 years. It was assumed that the response rate would be 70%, thus 700 children needed to be recruited for the required sample size.

3.1.4 Sampling

Results from the 2002 cross sectional study on nutritional status of preschool aged children from kindergartens in HCMC indicated that obesity among urban children was significantly higher than that among children from sub-urban areas (9.6% and 4.3% respectively, and obesity defined as Z-score for weight for height index > +2 SD based on 1978 WHO reference) (Hung et al., 2003). This study was designed therefore to be conducted in a kindergarten setting in urban areas where obesity was more prevalent among preschool aged children than in sub-urban areas. Based on general indicators and living standard, the urban areas of HCMC were stratified into two strata: wealthy areas which included districts 1, 3, 5, 10, and less wealthy areas which included districts 4, 6, 8, 11, Tan Binh, Phu Nhuan, Binh Thanh (Statistical_office_in_Ho_Chi_Minh_City, 2002). The study used a multistage cluster sampling method with two stages as below:

<u>Stage 1:</u> Based on the sampling frame of all kindergartens in 2005 with their population for both strata provided by the Department of Education, ten out of ninety-seven kindergartens from the wealthy districts were selected using probability proportionate to school size (PPS) sampling method. As the population was geographically widely dispersed in the less wealthy districts, four of these districts (districts 6, 11, Tan Binh, Binh Thanh) were

selected out from a total of 8 districts using simple random sampling, and then ten out of ninety seven kindergartens were chosen from these selected districts by the PPS method.

Stage 2: Lists of all children aged 4 to 5 years (born in the year 2000) in each of the 20 selected kindergartens were prepared by school collaborators, and 35 children in each school were randomly selected using systematic random sampling. The sampling strategy is summarised in Table 3-2. The sampling design required the construction of sampling weights which are described in the analysis section (Table 3-3).

Table 3-2 Summary of sampling method

Level	Unit sampled	Number of units sampled	Method used	Frame
1	Kindergartens	Total of 20 with 10 from each strata	PPS (population size of kindergarten) within each strata. Stratified by wealthy and less wealthy districts Wealthy districts strata – all 4 selected Less wealthy districts strata – 4 out of 8 selected by simple random sampling (SRS)	List of kindergartens by district
2	Children born in 2000	35 per school for total of 700	Systematic random sampling	List of children prepared for each selected school

3.1.5 Subjects and recruitment

Permission for conducting this study was obtained from the Department of Education of Ho Chi Minh City and the twenty selected schools were informed of the study by the District Office of the Department of Education. School collaborators were selected from teachers as suggested by the principals at the participating schools. The school collaborators were required to provide a list of children in their school to the investigators, for subject selection. They were then invited to participate in a training class about the enrolment procedures, conducted by the investigators. The school collaborators met the parents of each selected child, provided information about the study, invited the parents and children to join the study, and sought their consent. If selected subjects needed time for their decision, school collaborators contacted them again two to three days later for their response. The invitation from the school collaborators occurred at least one week before the survey day, which allowed sufficient time for consenting participants to arrange their activities to allow them to attend the survey clinic. The survey days were scheduled over two days so that parents had more chance to participate.

3.1.6 Measurements

3.1.6.1 Anthropometry

Body weight, height and skinfold thickness of the children were collected. Weight was measured with shoes and jackets removed, using Tanita electronic scales (Tanita BF 571, Japan) and recorded to the nearest 0.1 kg. Height was measured with shoes and hats removed, using a Microtoise tape suspended from a wall and recorded to the nearest 0.1 cm. Skinfold thickness in children was measured at three sites including triceps, subscapular, and suprailiac by Harpenden calliper (H.E. Morse Co. British Indicators, Ltd). Two repeated measurements were made. The first two measurements were more than 1mm different, or if in obese subjects the difference between the measurements was greater than 10%, then a third measurement was obtained.

Anthropometric measurements were collected by four physicians from the Nutrition Centre who were experienced in taking anthropometric measurements. Their methods were standardized as described in an anthropometric standardization reference manual (Lohman et al., 1991) before the data collection commenced.

Height and weight of the parents who participated in the survey days were also measured using standard methods.

3.1.6.2 Physical activity

The questionnaire assessing children's physical activity included parents' and teacher's reports. This questionnaire was modified from a parental proxy report of children's physical activity developed in the US (Metallinos-Katsaras et al., 2000). It was translated into Vietnamese and adjusted using qualitative information from interviews about the daily activities of children at home and preschool from of ten mothers of ten children aged 4 to 5 years and four teachers. A list of daily physical activities in this child population was prepared from the information gathered in the interviews of mothers and teachers, and these items of physical activity were compared with those in the original parental proxy questionnaire. The final proxy questionnaires for physical activity included items originally listed as well as others specific to the population in HCMC.

This proxy report questionnaire consisted of four items assessing the average time per day the child engaged in various types of sedentary behaviour and vigorous activity on both weekdays and weekend days over the three preceding months. There were three types of sedentary behaviours measured including TV viewing, naps and inactive light activities such as sitting with no trunk movement and sitting with limb movement, for example, playing video games, playing with toys or dolls, reading, painting, or playing with puzzles. The types of vigorous activities included jumping, running, climbing, sliding, hiding and seeking, tip and tag. This questionnaire was used to interview parents and teachers to assess physical activity in all children in this study. The questionnaire can be found in the Appendix 1.

3.1.6.3 Dietary intake

Dietary intake was measured in all children using a food frequency questionnaire (FFQ) adapted and modified from one that has been validated for preschool children aged 6 to 36 months in HCMC (Vu, Unpublished report). This validation study aims to evaluate reliability and validity of the FFQ assessing zinc intake and other nutrients in preschool children in sub-urban areas of HCMC in 2003. The preliminary food list was created from 24 hour recall. Other foods were identified from the food composition table and focus group discussion. There were total of 98 food items in the food list. The study was carried out all eligible children aged 6 to 36 months in a randomly selected ward of District 12 of HCMC. Response rate was 91.9% (182 out of 198). Short-term reproducibility was assessed by comparing the first versus the second interviews of the FFQ at one month apart. Long-term reproducibility was assessed by comparing the first and the third interviews of FFQ by interviews of four months. The validity study was conducted using six 24h-recalls as a reference method. The results of the validation study showed that the FFQ had high reliability and validity, especially for protein (0.41), zinc (0.52) and phytate (0.48) intakes.

The FFQ was modified using information collected through 24 hour recalls from forty eight children aged 4 to 5 years in urban areas of HCMC. The food list on the FFQ was compared with the foods reported in the 24 hour recalls. Foods reported in the 24 hour recalls that were not on the food list were considered for inclusion on the food list. Either these foods were grouped with existing foods on the list or were added. For example, sea-crab and river-crab meat in the group of meat and sea food, strawberries in the group of fruit and vegetables, steamed sticky rice and green bean paste in banana leaf were added to the food list. Foods on the FFQ food list that were not reported in the 24 hour recalls were also reviewed. They were removed if they were mainly baby foods such as breast milk or infant formula.

A food list worked out from the 24 hour recall data was checked with the food list in the available FFQ to adjust the food items in order to be more appropriate for children aged 4 to 5 years. The portion size of food items in the FFQ was adjusted by asking twelve mothers with children of similar age to identify the usual portion sizes served to their children. The frequency and portion sizes of the 89 food items in this FFQ were obtained with the help of visual aids (a real size picture book of portion sizes of different foods). The FFQ was used to assess dietary intake at home by interviewing parents or main caregivers, and at school by interviewing teachers. These interviews took about 15 to 20 minutes to complete. A copy of the FFQ can be found in the Appendix.

The FFQs were completed by interviewing the parents and teachers. The interviews were conducted by staff of the Community Nutrition Department of the Nutrition Centre, HCMC, who was experienced in obtaining dietary information with 24 hour recalls or FFQs. They were trained in the interviewing techniques to use with this FFQ prior to the survey.

3.1.6.4 Socio-demographic information and child characteristics

A pre-coded, structured, interview-administered questionnaire was prepared and used to gather soico-demographic information from the parents of the participants in this study. The questionnaire included the following items:

Child section

This section recorded information on the birth date and gender of each child. Clinical characteristics of the child and their mother were also captured and included the child's birth weight, maternal weight gain during this pregnancy, reports of gestational diabetes, gestational age, duration of breastfeeding, the number of siblings and average number of hours per night the child slept.

Parents section

This section recorded information on parental self-reported weight and height, household economic status, parental ethnicity, education level, and occupation. The economic status was measured by asking about ownership of assets from an inventory of seventeen household items. The list included household vehicle, entertainment appliances and other household appliances (Filmer and Pritchett, 2001). Parental education levels were recorded as, no schooling or primary school, secondary school, high school, college or university or higher. Data on parental occupation was also captured and classified as teacher or professional, government officer, small business or skilled worker, labourer or street or home trader and home maker or other. Details of this questionnaire are provided in the Appendix 1.

3.1.6.5 Environmental questionnaire

A questionnaire to assess obesogenic environments was developed by modifying the 'Home Observation for Measurement of the Environment Short Form' (HOME-SF) using information collected in focus group discussions (FGDs) with mothers who had children of similar age, and preschool teachers from urban areas in HCMC. The HOME-SF is an abbreviation of the full HOME assessments used to assess the quality of the child's environment in the National Longitudinal Survey of Youth in the United States and it has established reliability and validity (Bradley, 1993, Strauss and Knight, 1999). It consists of two subscales measuring the aspects of the home environment related to the cognitive and emotional development in infants and toddlers (0 to 3 years), in early childhood (3 to 6 years), and in middle childhood (6 to 8 years). The HOME-SF for early childhood was translated into Vietnamese and modified appropriately for use in the preschool child population in HCMC based on data from FGDs. The final questionnaire was interview-administered and structured with three sections for home, preschool, and neighbourhood environments.

Four FGDs were separately conducted for mothers and teachers in kindergartens with eight to ten participants in each of the FGD. The participants were volunteers from two convenient preschools, one from a less wealthy district and the other from a wealthy district. The FGDs were carried out using a prepared interview guide focusing on perceptions of environmental factors in the family, neighbourhood, preschool and community that potentially could affect a child's health including diet, physical activity, emotional support and cognitive stimulation from parents or other adults in the family. With permission, these 30 to 40 minute discussions were tape recorded, transcribed, and checked for accuracy. The key information from these discussions was compared with the contents of the HOME-SF. The HOME-SF also included items used in direct observation at the child's home, such as "how clean and organised is the child's family house", and these items were removed from the questionnaire. Thus, the environmental questionnaire was composed of items to measure the environment at home and in the neighbourhood. For the home environment, information on cognitive and emotional stimulation as well as home food availability was collected. The aspects of neighbourhood environment that were assessed included the accessibility to restaurants or outlets selling energy dense food, accessibility to game shops, availability of facilities for outdoor activities, such as playgrounds or parks around homes, and the parents' perspective on the safety of the neighbourhood environment for physical activity for young children. The questionnaire can be found in the Appendix 1.

Information on the preschool environment was collected by interviewing the preschool principals. They were asked about the size of the preschool, the number of items of play equipment, the time allocated for physical education, the number and type of activities permitted during break times per school day. Government regulations on selling food within the preschool are strict, and canteens may not be opened in kindergartens. Even the variety of food supplied by parents for the child to eat at preschool is limited, except for milk. With regard to the food environment around preschool, information on the availability of snack food, sweets, ice-cream, soft drink that can be sold around the preschool (within a radius of 200 meters) was also collected. The details of the home and preschool environment questionnaires can be found in the Appendix 1.

To assess the content, language, and feasibility of the questionnaires before starting the survey, the set of questionnaires used in this study was piloted with 20 mothers, who had children of the same age as those in the survey and who were attending clinics at the Nutrition Centre.

Socio-demographic and environment information was also collected by the interviewers who were trained prior to the commencement of the study.

3.1.7 Data collection

3.1.7.1 Training

Anthropometric measurements were collected by four physicians from the Nutrition Centre who had experience in collecting anthropometry data. They had one day of training on the techniques for measuring weight, height and skinfold thickness using standardized methods adapted from anthropometric standardisation reference manual (Lohman et al., 1991). Eight children and eight adults were invited for this standardisation exercise. A measurer and assistant were paired with a child at the beginning of an exercise. After the supervisor's instruction, the measurer took the measurements and recorded the results on the anthropometric standardization form next to the child's identification number. Once the results were recorded, corrections were not allowed. When all the measurers had conducted their measurements, the supervisor instructed them to move to the next child, following the numerical order and requested that they wait for instructions to begin the measurement.

This process was repeated until all children had been weighed and measured by all the measurers. Talking between measure-pairs during this exercise was not allowed. The supervisor took advantage of the standardization exercises to systematically observe each measurer's performance using the Measurement Techniques Observation form (Cogill, 2003) containing a list of the most important steps of each measurement technique. These observations allowed the supervisor to record if each step was completed appropriately, and were used in discussions with the measurers at a later time.

The difference between the measurements of each of the measurers and the standard measurement were calculated and the size of the difference indicated the level of the problem in the measurement technique. Measurers with significant differences in their measurements compared with the other measurers undertook further training for that measurement.

Staff, including physicians, dieticians and medical students from the Nutrition Centre were trained for two days on interviewing techniques and the use of the survey questionnaires, before the study commenced.

In the training classes for local preschool collaborators, the following topics were covered: techniques for inviting parents and children; approaches to recruitment and obtaining consent; and how to receive participants on the clinic day. Preschool collaborators were also trained to prepare the clinics for data collection at the preschools.

3.1.7.2 Data collection schedule

To assess the content, language, and feasibility of the questionnaires before starting the survey, they were piloted with twenty mothers attending clinics at the Nutrition Centre, who had children of the same age as those in the survey. The baseline study took place at the selected preschools during March and April in 2005. Each preschool was visited twice giving all children and their parents more chance to participate. Measurements including anthropometry, dietary intake, physical activity and information on socio-demographic and child's characteristics were taken in this data collection.

At follow-up, the second data collection was conducted at 6 months after baseline, from September to October in 2005. The third data collection was carried out at 12 months after baseline, from March to April in 2006. Anthropometry, dietary intake and physical activity were assessed in the follow-up measurements. In the third measurement, more information on breast feeding and feeding practices during infancy was also collected including exclusive breast feeding, formula feeding and introduction of complementary foods.

Clinics were prepared by preschool collaborators who were trained in advance. The survey team brought all equipments and supplies for the survey including the electronic scales, skinfold callipers, and circumference tapes to the clinic every day.

3.1.7.3 Retention

There were a number of activities done to minimise the loss of follow up in this cohort study. After data collection at each occasion was completed, the results of the child's nutritional status were sent to the parents coupled with a reminder for their participation in the next round of data collection time. During one year of study, preschool teachers kept updating the information on the child to see if the child still attended the preschool or had moved to another place. This update was sent to the investigators every month. A number of children who moved to other preschools were invited to continue participating, based on the updated information. Preschool teachers also cooperated in reminding and encouraging the parents about the study.

3.1.8 Data entry and analysis

3.1.8.1 Data entry

Data for each round of the data collection was entered into computer files using the Epi-Info program (version 6) with standardized procedures and data check files. All data were examined for missing values and outliers, and cleaned by checking with the questionnaire prior to data analysis. Data was analysed using the STATA version 9.2 (2005; Stata Corporation, College Station, TX, USA). Categorical data were tested with Pearson chi-square using two tailed significance tests, and the comparison of two groups of normally and non-normal distributed continuous data were tested with Student's t-test and Wilcoxon rank sum test.

3.1.8.2 Data analysis

All analyses were performed using STATA version 9 (2005, Stata Corporation, College Station, TX, USA). Stata "svyset" commands adjusted the analyses for the stratified two-stage cluster sampling design using Taylor linearized variance estimation. Sampling weights for each stratum were calculated for use with the "svyset" commands as in Table 3-3 below.

Table 3-3 Sampling weights for each stratum for the 2005 survey

Sampling weight for each stratum based on the number of children aged 4 to 5 years attending kindergartens in urban areas of HCMC in 2005

Strata	Population in sampled districts (nh)	Total population of districts in stratum (Nh)	Final sampling fraction	Stratum sampling weights (Nh/N)/(nh/n)	Standardized weight
Wealthy districts	10,732	10,732	1.000000	0.729323	0.706432521
Less wealthy districts sampled	14502	26555	0.54611184	1.335483413	1.293567479
Total (n, N)	25, 234	37, 287			

Construction of household wealth index

Household economic status was assessed using an index of household assets and facilities. The index was constructed using an established, principal component analysis method to weight the contribution of each asset to the index (Filmer and Pritchett, 2001).

The first principal component output was used as a scoring factor to weight each of the assets or facilities in the wealth index. The wealth index for each household (Wj) was calculated using the following formula:

$W_j = f_l \times (a_{j1} - a_1) / (s_1) + ... + f_N \times (a_{jN} - a_N) / (s_N)$

Where f_l is the "scoring factor" for the first asset as estimated by the first principal component, a_{j1} is the $_j$th household's value for the first asset and a_1 and s_1 are the mean and standard deviation of the first asset variable over all households. The score for each asset is summed over the N assets used to construct the index.

Once calculated, the wealth index was used to rank families by their wealth status. The highest tertile of wealth index represented the wealthiest group and the lowest wealth index tertile represented the poorest group.

This index has been reported to be as reliable an indicator of household economic status as an assessment of household expenditure or income (Filmer and Pritchett, 2001).

Socio-demographic and child's birth history

The education level of parents was categorized as primary, secondary, high school and college or university. Parental occupation was divided in six groups including teacher or professional, government officer, small business or skilled worker, trader, labourer or street trader, and home maker or other.

Breast feeding was defined as children who were ever breastfed and the duration of breastfeeding (measured in months) was used as a continuous variable. The child's birth weight was divided into the following four categories: <2500 grams, 2500-2999 grams, 3000-3499 grams and ≥ 4000 grams. The average amount of time spent sleeping at night (measured in hours) was analysed as a continuous variable. Recalled diagnosis of gestational diabetes in this child's pregnancy was treated as two categories of presence or absence. Pre-pregnancy maternal overweight status was assessed based on BMI with cut-off points recommended for Asian adults (Corazon et al., 2004). See the section about assessment of nutritional status of parents below for further details. Maternal weight gain during this child's pregnancy was also considered and analysed as a continuous variable.

Assessment of nutritional status in children

Body mass index (BMI: kg/m^2) was calculated from the measured height and weight. The age-and gender-specific BMI cut-off points proposed by the International Obesity Task Force were used to define overweight and obesity in the children (Cole et al., 2000). The terms of overweight or obesity refer to overweight or obesity only, while overweight/obesity refers overweight and obesity combined. This approach was developed using national reference datasets from six countries (U.K., U.S., Singapore, Netherlands, Hong Kong, and Brazil) in which Z-score values for BMI of 25 and 30 kg/m^2 at age 18 years were used to define equivalent Z-score values for BMI in younger aged children (Cole et al., 2000).

Another definition of overweight based on the WHO Child Growth Standard (WHO, 2006) recently developed for children under 5 years was also used to assess overweight in children younger than 5 years. Due to the lack of a clear recommendation for defining overweight in children under five years of age using the new standard, this study employs the cutoffs of +2 SD and +3 SD for classifying overweight and obesity respectively based on the new WHO standard.

Weight-for-age, height-for-age, and BMI were expressed as Z-scores of the CDC 2000 Growth Reference which was used to calculate the anthropometric indicators of underweight, stunting, and wasting. The cut-off point for weight-for-age, and height-for-age and BMI used to define underweight, stunting, and wasting was the 5th percentile of the CDC 2000 Growth Reference (Kuczmarkski et al., 2000). The frequency of children in narrow ranges of BMI-for-age Z-scores from the CDC 2000 Growth Reference were plotted and smoothed with a Lowes function to construct BMI Z-score frequency distribution curves (Chambers et al., 1983).

Nutritional status of parents

BMI calculated from self-reported parental weight and height was also used as an indicator to assess the overweight/obesity status of the parents. The number of parents with measured weight and height (136 fathers and 450 mothers) was not sufficient for analysis. Parental self-reported BMI and measured BMI were strongly correlated in both parents (women: $r = 0.97$, $p < 0.001$, men: $r = 0.96$, $p < 0.001$). The Kappa statistic also showed good agreement between categories of self-reported and measured parental BMI status with values ranging from 0.88 for men to 0.92 for women. Misclassification of overweight as normal weight in women (27.1%) was higher than in men (18.0%) (Table 3-4).

New cut-off points have been proposed for Asian populations in which overweight is defined as BMI ≥ 23 kg/m^2 and obesity as BMI ≥ 27.5 kg/m^2 (Corazon et al., 2004). Recently, the optimal cut-off points for BMI classification as overweight and obesity developed for adult population in HCMC were similar to those proposed by WHO for Asian population (Cuong, 2004).

Table 3-4 Comparison of categories of self-reported and measured parental BMI status as normal or overweight

True parental BMI	Reported paternal BMI		Reported maternal BMI	
	<23 kg/m^2 n (%)	≥23 kg/m^2 n (%)	<23 kg/m^2 n (%)	≥23 kg/m^2 n (%)
<23 kg/m^2 n (%)	70 (93.3)	11 (6.7)	320 (99.4)	2 (0.6)
≥ 23 kg/m^2 n (%)	5 (18.0)	50 (82)	35 (27.1)	94 (72.9)

[1] *Overweight in parents defined as BMI ≥23 kg/m^2 (Corazon et al., 2004)*

Dietary intake

Energy intake and macronutrients for each child in each round were calculated using the following formula:

[Reported daily frequency of consumption] * [Reported portion size for each food item] * [Standard portion size in grams of that food item] * [Nutrients per 100 gram]

Data on standard portion size and nutrients per 100 grams were obtained from the Vietnam National Food Composition Tables and the Vietnam Nutrients and Composite Foods Database Software (Eiyokun-Nutrition Centre HCMC) (Hanh, 2004). Energy and nutrient intake for each food item was then added up to obtain the total intake score per day for each subject. Observations with implausible energy intakes were excluded (<500 kcal per day or >5000 kcal per day) (Rockett et al., 1997).

To take into account food intake from preschool during five school days and home settings during seven days, the average amount of each nutrient intake per day was computed by weighting the amount of that nutrient reported by teacher and that nutrient reported by parents using the “weight”. The “weight” was calculated as below:

Average amount of each nutrient per day = [reported nutrient by teacher + reported nutrient by parents] * 5/7 + reported nutrient by parents * 2/7

Group means ± SD and 95% confidence intervals by gender in each round, adjusted for cluster sampling, were calculated. In terms of evaluating the relationship between dietary intake with the development of body fatness and overweight and obesity, 'energy-adjusted' macronutrient intakes were computed as the residuals from the regression model in which energy intake was the independent variable and absolute nutrient intake was the dependent variable, using the method of Willett (Willett and Stampfer, 1998). The total intake scores were classified into tertiles from lowest, middle and highest to rank the level of nutrient intake. Nutrient intakes were also expressed as percent of total energy intake and then were categorized into tertiles.

Physical activity analysis

The average amount of time in hours per day that the child was involved in sedentary activity, including TV viewing, naps and inactive plays such as video games, playing with toys, dolls or puzzle, reading or painting, and vigorous activity, was estimated from proxy reports given by parents and teachers. This approach took into account the time spent in physical activities in both preschool and home settings during weekdays and weekend days. The amount of time the child engaged in sedentary behaviour and vigorous activity on a typical weekday was summed from data given by the teacher and the parents, except for TV viewing since TV viewing only occurred in the home setting. The amount of time the child spent on each type of physical activity per day was calculated using data for physical activity on a typical weekday with data for that type of physical activity on a typical weekend day, reported by parents using the "weight". The "weight" used was calculated as follow:

Average amount of time for sedentary behavior or vigorous activity per day = Time spent for sedentary behavior or vigorous activity per day during weekdays (hours) * 5/7 + time spent for sedentary or vigorous activity per day * 2/7 (5 weekdays and 2 weekend days).

The distributions of time for sedentary behaviour and vigorous activity were computed. In addition, the percentage of sedentary time in a day was calculated from the time spent in sedentary activity and the total time that the child was awake during a day. Group mean values for sedentary and vigorous activity with the 95% confidence intervals were calculated, after adjustment for cluster sampling. Average duration of time for sedentary behaviour including TV viewing, physical inactivity and naps, TV viewing only, vigorous activity and percentage of sedentary time in a day were examined as continuous variables in relation with the outcomes of interest.

Analysis of environmental factors

The neighbourhood context was assessed including whether or not the child's residence was located in a wealthy district or a less wealthy district, the accessibility to Western fast food restaurants and local stores selling energy-dense foods, the availability of computer/video game shops and play grounds nearby. Also recorded were parental perceptions on the safety of the neighbourhood for outdoor activities of children. All these variables were coded with "1" as presence and "0" as absence.

Information on the environment at preschool consisted of the size of the play ground and the number of items of play equipments, which were analysed as continuous variables. Based on items assessing the availability of snack, sweets, ice-cream, soft-drink and fried food around preschool, a score for the preschool food environment was computed using principle factor analysis in which the availability of sweets and junk foods were assigned as "1" and "0" for absence. Using this approach, the least number of factors which can account for the common variance (correlation) of a set of variables was identified. This score was ranked into groups using tertiles. The highest score group represented the preschools with easiest child access to sweets, snacks and other energy-dense foods and the lowest tertile represented those preschools with the least child access to these foods around the preschool.

For the home environment, scores of cognitive stimulation and emotional relationship between parents and the child were determined using principle factor analysis. There were nine items collected for cognitive stimulation including the frequency of taking the child on any kind of outing, the frequency of reading stories to the child, helping the child to learn numbers, colours, alphabet, shapes and sizes, the number of children's books and CDs the child have, and whether the child had been prepared for primary school. Emotional items included the size of the family, the frequency that parents played with the child, the frequency of eating meals with both mother and father, the extent of choice the child had in choosing foods, the average amount of time in a typical day that the mother spent away from the child, whether the child had pocket money and parental regulation of playing computer or video games as well as TV viewing.

Once established, these scores were divided into tertiles. Higher scores represented a higher cognitive stimulation and emotional relationship between parents and the child. In addition, the home food score was estimated using factor analysis based on the availability of a number of foods. The presence of nutritious food items such as vegetables, fruits, meat, egg and milk were coded as "1" while the presence of less nutritious food items, such as sweet, ice-cream, soft drinks and canned foods were coded as “0”. The score was then categorised in three equal groups using tertiles. The highest group referred to a more appropriate home food environment and the lowest group referred to a less desirable home food environment. The questionnaire for assessing the home environment can be found in the Appendix 1.

Socio-demographic factors and overweight/obesity at baseline

With baseline data, the distribution of weight, height and BMI were described by mean and standard deviation for the socio-demographic groups. The prevalence of overweight, obesity, and underweight together with 95% confidence intervals were calculated across the socio-demographic groups. The associations between child characteristics, household socioeconomic status, parental characteristics, parental overweight/obesity status with overweight/obesity in children were examined using prevalence ratios (Aluísio and Vânia, 2003) in univariate and multi-variable Poisson regression analyses with robust variance estimates.

Analysis of cohort data

An hierarchical conceptual framework was employed to guide the regression analysis (Victora et al., 1997). The inter-relationships between exposures, including the child’s characteristics, their dietary intake and physical activity, household socioeconomic status, parental characteristics, maternal pre-pregnant overweight status, weight gain during pregnancy, and family, preschool, community environmental factors and changes of BMI, skinfold thickness, development of overweight and or obesity, were examined using Generalized Estimating Equations models (Twisk, 2003).

3.1.9 Ethical consideration

After gaining permission from the Department of Education of Ho Chi Minh City, an initial meeting for all selected preschools was organised and information about the study was presented. Information sheets and consent forms for the parents were distributed and collected before data collection commenced. The research protocol was submitted to the Human Research Ethics Committee of the University of Newcastle, Australia and the Health Service of HCMC Vietnam for their approval before the study began.

As some of the questions were personal, interviewers informed subjects prior to the interview, that they could refuse to answer any question if they so wishedo. In addition, the privacy of the interview was ensured by conducting it in a small interviewing room.

Private information, such as name and address of the participant, was kept separately and linked with questionnaires by codes. Access to this information required permission from the principal researchers. Final data sets did not include any personal identifier. All questionnaires were destroyed when data had been entered and cleaned.

After each round of measurement, preschool collaborators informed participants of their child’s nutritional status (either under nutrition, overweight or obesity) in writing, from documents prepared by the investigators. Participants with abnormal status were referred to appropriate health care services for further evaluation, counselling or treatment if needed.

3.2 Validation of physical activity questionnaire

3.2.1 Study population and setting

A subset of children and their parents from the entire sample in the cohort study was invited to participate in the validation study of the proxy questionnaire assessing physical activity in children aged 4 to 5 years. This validation study was undertaken from September to November in 2005.

3.2.2 Study design

This study aimed to validate an existing parental proxy questionnaire, developed to assess physical activity in children aged 2 to 5 years in the US for use in children aged 4 to 5 years old in Ho Chi Minh City, Vietnam. Activity counts from Actigraph accelerometers (Actigraph, LLC, Fort Walton Beach, FL) were employed as the criterion method.

3.2.3 Sample size and sampling

Ninety children from the entire cohort study were invited to participate in the validation study. These children were recruited from ten preschools, randomly selected from twenty preschools in the cohort study. Nine children were randomly chosen in each of the ten selected preschools. Of eighty three children whose parents agreed to participate, thirty two children were replaced by volunteers from the entire cohort sample because of a low response rate from parents in some selected preschools.

3.2.4 Measurements

Teacher and parental report questionnaire

The questionnaires for parents and teachers to assess the children's physical activity were based on a parental proxy report of children's physical activity developed in the US (Metallinos-Katsaras et al., 2000). As mentioned in section 3.1.6.2, they were modified using information from interviews about daily activities of the child at preschool and home with teachers, and parents who had children of similar age. The form consisted of items estimating the time the child spent on various sedentary behaviours including inactive light activity, such as sitting with no trunk movement and sitting with limb movement, time spent viewing TV or watching video, and time spent for their daily nap. In addition, information about the time the child usually slept at night and the time they woke in morning was collected. Duration of engagement in vigorous activity was also asked. The teacher's form captured information on sedentary behaviour, vigorous activity at the preschool on a typical weekday. The parents' form captured information about sedentary behaviour and vigorous activity in home setting on a typical day for both weekdays and weekends.

These proxy report forms were used to measure physical activity at the baseline and two follows-up that were six months apart in the one year cohort study. Physical activity data collected at the first follow-up (from 9 of September to 27 of November in 2005) were used for the validation study because they were matched with the time for collecting data from the criterion method.

Accelerometer measurements

Data collected from the Actigraph accelerometer, model 7164 and GT1M accelerometers (Actigraph, LLC, Fort Walton Beach, FL), were used as the criterion measure. Both models have the same measurement features. The Actigraph is a single axis accelerometer designed to measure and record time varying accelerations ranging in magnitude from approximately 0.05 to 2 G's with a frequency response of 0.25-2.50 hertz. They were initialised using a compatible computer with a reader interface unit for the 7164 model or USB connection for GT1M model that configures the monitor to switch on and off at specified dates and times (Actigraph, 2004). In this study, data was collected in a 1-min epoch.

These small size and light weight monitors (Actigraph 7164: 5.0 x 3.8 x 1.5 cm and weight of 42 grams; GT1M: 3.8 x 3.7 x 1.8 cm and weight of 27 grams) do not interfere with the daily activity of young children. Validation studies of this measurement instrument have shown they are a valid and reliable measure of children's physical activity (Fairweather et al., 1999, Kelly et al., 2004). A relative high correlation coefficient between direct observation and the CSA accelerometer during a preschool exercise class was reported ($r = 0.87$) (Fairweather et al., 1999). Similarly, using direct observation to evaluate the validity of Actigraph in 78 free-living children 3 to 4 years old, a high correlation between mean Actigraph counts and the mean activity score from the observational system was reported ($r = 0.72$) (Kelly et al., 2004). Accelerometers are one of the methods suggested for use as a criteria measure in validation studies of methods of measuring physical activity in children (Kohl et al., 2000).

Data from accelerometers was collected from July 24 to October 27 in 2005. Children participating in this validation study wore the accelerometers on their right hip, attached with an adjustable elastic waist belt for seven consecutive days. Parents were instructed to put it on the child each morning when the child woke and to take it off during sleep, showering and swimming. At the preschools, teachers removed the monitor during nap time and replaced after the midday nap. To maximize the compliance with wearing the accelerometers during preschool days, teachers would remind parents about putting the monitors on the child in the morning. Both teacher and parents were provided with logs to record the time the monitor was attached and removed.

3.2.5 Data process and analysis

The data from teacher and parents' forms were used to calculate an average time spent for sedentary behaviour and vigorous activity as presented in detail in section 3.1.2.8. In short, it took into account time spent on physical activities in both preschool and home settings for both weekdays and weekends.

Data from the accelerometers with minute by minute activity counts were uploaded to a data reduction program (QBASIC) for determination of time spent in sedentary behaviour (< 1100 counts/min) and non-sedentary (≥ 1100 counts/min). This cut off has demonstrated a high sensitivity (83%) and specificity (82%) in quantifying sedentary behaviour in children aged 3 to 4 years indicating that accelerometers can provide an objective assessment of engagement in physical inactivity by young children (Reilly et al., 2003a).

Variables on sedentary behaviour and vigorous activity from the questionnaire were examined for missing values and outliers, and cleaned by checking the questionnaire prior to data analysis. All variables on sedentary behaviour and vigorous activity, from questionnaires and accelerometers, were checked for normality.

To examine the validity of the questionnaire, Spearman's rank correlation coefficient was used for non-normally distributed variables from both the questionnaire and the accelerometer. Bland-Altman analysis was also applied using graphs to evaluate the level of agreement between two measurements of sedentary behaviour.

3.2.6 Ethical considerations

Participation in this validation study was entirely voluntary. Teachers, children and their parents were fully informed of all aspects of the proposed research and an information sheet was distributed to the parents for their consideration. One week after the initial invitation, the parents were approached at preschool to obtain their written consent. If the parent and children were willing to participate, the consent form was signed by parents. The parents and their child were free to accept or refuse to participate in the study. Only parents and their child, who had been fully informed and had consented, took part in the research. Participants were assured of their rights to confidentiality. Private information was kept separate and linked with questionnaires by codes. The participants were assured that publication of results would not use specific information that could identify individuals. Participant identifiers were coded by the interviewer and the personal identifiable information was removed before data entry. A reversed coding information sheet was kept by the chief investigator for supervising and monitoring purposes only. Only research staff was allowed access to records or computer files. All information with personal identifiers was stored in a locked filing cabinet at the Nutrition Centre. Once data linkage was completed and cleaned, and archived computer data files prepared, the paper records were destroyed. The study proposal integrated in the entire cohort study was reviewed and approved by the Human Research Ethics Committee of the University of Newcastle, Australia.

3.3 Trends in overweight and obesity

3.3.1 The 2005 cross sectional study

This was the baseline component of the longitudinal study on children aged 4 to 5 years previously described in detail in section 3.1.1.

3.3.2 The 2002 cross sectional study

3.3.2.1 Study design

This cross sectional study aimed to evaluate the prevalence of overweight and obesity by assessing the nutritional status of children aged 1 to 6 years who attended kindergartens in Ho Chi Minh City in November 2002. This data was used to examine the trends in overweight and obesity in preschool children by comparing the results with the results of the 2005 survey. This examination of the trends in overweight and obesity from 2002 to 2005 was restricted to the data in the 2002 survey of children aged 4 to 5 years living in the urban areas of Ho Chi Minh City.

3.3.2.2 Study population and setting

The reference population in this study was preschool children aged 1 to 6 years of both genders living in urban areas of southern provinces and cities of Vietnam. The source population were preschool children from 1 to 6 years of age attending kindergartens in the whole of HCMC, Vietnam. As presented above in the Methodology section for the longitudinal study, HCMC consists of twenty two districts classified in urban areas with twelve districts and sub-urban areas with ten districts. In the year 2002, there were 540 kindergartens in the whole of HCMC in which the number of children under 6 years attending kindergartens in urban areas and sub-urban areas was approximately 92,400 and 51,600 respectively (Department_of_Education, 2002).

3.3.2.3 Sample size

This study was designed to assess the nutritional status of children who attended kindergartens in Ho Chi Minh City. The sample size was determined using the formula for estimation of a single proportion as below:

$$n = \frac{Z_{\alpha}^{2} p(1-p)}{\Delta^{2}}$$

where:

Z_{α} = the coefficient of statistical significant - alpha

Δ = the width of the confidence interval

p = an expected proportion of individuals in the sample with overweight

Assuming the level of statistical significance of alpha was 5% then $Z_{\alpha} = 1.96$, and the width of the confidence interval for the true value of Δ was 0.05. The 2001 cross-sectional study assessing the overweight status of kindergarten children in one of twenty two districts in HCMC reported a prevalence of 7.9% children who were overweight (defined as weight-for-height index >+2 SD – WHO 1978 reference population). Therefore, the value of the p value used was 0.079 (Huong and Hung, 2002). A calculated sample size for each age group was 112 children and the total number of children for six age groups from 1 to 6 years old was estimated to be 672 children. Assuming a design effect of two from the cluster sampling design and an expected response rate of 75%, the required sample were 1792 children and that was rounded up to 1800 children.

3.3.2.4 Sampling

This study used a multistage cluster sampling method with two stages. In the first stage, the proportionate to school population size (PPS) method was used to select 60 kindergartens from a prepared frame of all kindergartens in the whole of HCMC. There were 30 children with an age range from 1 to 6 years recruited from each of the selected preschools using systematic random sampling based on a prepared list of all the children in each preschool.

3.3.2.5 Subjects and recruitment

The selected preschools were invited to participate in this study after obtaining permission from the Department of Education of Ho Chi Minh City. Preschool collaborators prepared lists of all children in their preschools and provided them to the researchers for selecting the number of participants. They were also trained on how to invite the subjects and the data collection procedures.

The trained preschool collaborators presented an explanation of the study and the participation required, to the parents of selected subjects. An invitation to join the project follows. If the parents of the selected subjects needed time to consider their participation, they were contacted again some days later for their response. This time period was enough for the participants to think carefully before deciding to participate in the study. This task was completed under the supervision of the primary investigator.

3.3.2.6 Measurements

Anthropometry measurements

The anthropometric measurements were collected by six medical doctors from the Nutrition Centre who were trained following a standardized protocol about anthropometric measurement before data collection. Weight was measured with shoes and heavy clothes removed using Tanita electronic scales (Tanita BF 571, Tanita Corporation, Japan) and was recorded to the nearest 100g. Height was measured with shoes and hat removed using a Microtoise tape suspended from a wall and recorded to the nearest 0.1 cm using standard methods (WHO, 1995). The survey instruments were calibrated before taking measurements on each day of the study.

Socio-demographic information, child's birth history and feeding habits

Information on socio-demographic status, child's birth history and eating habits were collected using a self-administered questionnaire distributed to the parents at least one week prior to the survey at the preschools. The information collected included the highest education level of parents, parental self reported weight and height, child's weight at birth, whether the child was breast fed, the average amount of time per night that the child slept, and the frequency of consumption of fast food, soft drink, sweets, ice-cream, and vegetables. The completed questionnaires were returned to the investigators to check for missing data and missing data was collected during the following contact with the parents.

3.3.2.7 Data analysis

Anthropometric analysis

BMI (kg/m^2) in children was calculated and the age- and gender- specific BMI cut-off points recommended by the International Obesity Task Force (Cole et al., 2000) were used to define overweight and obesity among children age 4 to 5 years in the two studies. The weight for age z-scores, height for age z-scores and BMI z-scores were calculated based on the 2000 CDC Growth Reference (Kuczmarkski et al., 2000) and the 5^{th} percentile was the cut-off point used to classify underweight, stunting and wasting in this child population.

The overweight status of parents in both studies was assessed based on the BMI calculated from self-reported weight and height using the cut-off points of 23 kg/m^2 recommended for Asian populations (Corazon et al., 2004).

Adjustment for sampling design in both studies

Stata "svyset" commands, which use Taylor linearized variance estimation, adjusted the analyses for the cluster sampling design in both studies. Details of the "svyset" commands used in the 2002 and 2005 studies are described in Chapters 4 and 5. The sampling weights for each stratum were calculated for use in the 2002 study as set out below. Table 3-5 shows the weights were close to one because of the self-weighting proportionate to population size sampling design. Whilst the weights calculated for the 2005 study (Table 3-3) differed from one because the sampling was stratified by wealthy and less wealthy districts.

Table 3-5 Sampling weight for each stratum for the 2002 survey

Sampling weight based on the number of children aged 4 to 5 years attending kindergartens in urban areas of HCMC in 2002

Strata	Values for variable: stratum	Sampled children in stratum (nh)	Total population of districts in stratum (Nh)	Final sampling fraction	Stratum sampling weights (Nh/N)/(nh/n)	Standardized weight
Wealthy districts	1	166	21,894	0.007582	1.009547	1.007187317
Less wealthy districts	2	326	42,383	0.007692	0.995139	0.992812683
Total (N/n)		492	64,277			

3.3.2.8 Ethical considerations

Principals of selected preschools were first informed of the research by the Department of Education of Ho Chi Minh City. Then a meeting where researchers presented information about the procedures of the study, was held for all selected preschools. Parents of selected children received an invitation letter to consider participation in this study for one week. After agreeing to participate, the questionnaires were distributed on the day of the meeting at their preschools. The participants' parents were also informed that participation was voluntary and entirely their choice, and that they could withdraw at any time without having to give a reason. They were also informed that if they decided not to participate, or to withdraw from the project, they would not be disadvantaged in any way. Furthermore, if they decided not to participate further in the research, they could request that all data collected from them be withdrawn.

Chapter 4 Prevalence of overweight and obesity

4.1 Introduction

Childhood obesity is not limited to the industrialized countries. The prevalence of overweight and obesity is increasing at an alarming rate in child populations in many Asian countries (Sakamoto et al., 2001, Luo and Hu, 2002, Tee, 2002). Rapid economic improvement along with changes in lifestyle including diet and physical activity patterns are thought to be responsible for this epidemic (Popkin, 2001). Obesity among preschool children is of concern because it may lead to obesity in later life, along with long-term adverse health consequences (Dietz, 1998, Reilly et al., 2003b, Lobstein et al., 2004, Monteiro and Victora, 2005). Due to the economic burden of childhood obesity, in terms of current and future health care costs, effective prevention should commence at preschool age (Mahshid et al., 2005, Reilly, 2006b).

Since the reform (Doi Moi) of the economic system in 1986, Vietnam has undergone dramatic changes in economic development. Ho Chi Minh City (HCMC) is one of the largest cities in Vietnam and has the highest rate of economic development in the country (Bureau_of_Statistics, 2002). This rapid economic development has produced an effect on the nutritional status of children similar to that seen in other developing countries. A “nutrition transition”, that is, a dramatic improvement in under-nutrition resulting in over-nutrition and related disease, is taking place (Popkin, 1994, 2002b). The nutrition surveillance of preschool children in HCMC over the last five years has shown that the prevalence of underweight, defined as weight for age index <-2 Z-scores, based on the 1978 WHO international growth reference (WHO, 1995), has declined rapidly, at about 8%

over the period from 1999 to 2004. Meanwhile, the prevalence of children with weight-for-height index >+2 Z-scores based on the same reference, has increased from 2.2% in 1999 to 6.0% in 2004 (Vu et al., 2005). Using the WHO definition (WHO, 1995), a survey of the nutritional status of preschool aged children from kindergartens in Ho Chi Minh City in 2002, reported that 7.8% of children were overweight with the magnitude of overweight more severe in urban areas (9.6%) than in sub-urban areas (4.3%) (Hung et al., 2003).

There has been no study of overweight that is representative of preschool children in urban areas of HCMC using BMI as an indicator for adiposity and the international age- and sex-specific BMI cut-off points proposed by the International Obesity Task Force (Cole et al., 2000). This study aims to assess the prevalence of overweight and obesity using the International Obesity Task Force definition, and identify the associated socio-demographic factors in a population of preschool aged children in the kindergarten system of Vietnam's largest city.

4.2 Methodology

The survey methods used in this study are described in detail in Chapter 3. Furthermore, to allow direct comparison with other studies on prevalence of overweight and obesity in preschool children in HCMC, re-analysis was also performed with accessible data using the definition for overweight/obesity recommended by IOTF.

Statistical analysis

Analyses were performed using STATA version 9 (2005, Stata Corporation, College Station, TX, USA). The distribution of weight, height and BMI were described by mean and standard deviation by socio-demographic groups. The prevalence of overweight, obesity, and underweight together with 95% confidence intervals using both IOTF definition (Cole et al., 2000) and new WHO Child Growth Standard for children under 5 years of age (WHO, 2006), were calculated across socio-demographic groups.

Pearson chi-square was used to test categorical data and Student's t-test was used for normally distributed continuous data. One way ANOVA was employed to test for the differences of mean weight, height and BMI among different groups. The Bonferroni test was conducted for pair-comparisons as needed. Two tailed significant tests were used in all analyses. Additionally, the comparison of prevalence was also made based on the 95% confidence interval.

Stata "svyset" commands that use Taylor linearized variance estimation, adjusted the analyses for the stratified two-stage cluster sampling design.

The following "svyset" commands were used to adjust for the sampling design:

```
svyset school [pw=Dpw], strata(Dstrata) fpc(Nschool_stratum) || Child_ID,
fpc(N_2000_children)
```

where :

> "school" is a variable to identify the kindergartens sampled for this study and are referred to as the primary sampling units
>
> "Dpw" is a variable to weight the results based on the population size of children born in year 2000 of each strata in stage one
>
> "Dstrata" is an indicator variable for the strata in stage one

“`Nschool_stratum`” is the total number of schools in each stratum which serves as a finite population correction (fpc) factor for the sampling in each stratum

“`Child_ID`” is a variable to identify each child selected in each kindergarten

“`N_2000_children`” is the total number of children in each selected kindergarten in stage one which serves as a finite population correction (fpc) factor for the sampling in each school.

Sampling weights for each stratum calculated for use with the “svyset” commands are presented in Chapter 3 (Table 3-3).

The associations between overweight and obesity with socio-demographic, parental, and other characteristics, were assessed using prevalence ratios (PR) (Aluísio and Vânia, 2003) in univariate and multi-variable Poisson regression analyses with robust variance estimates. Model building began with univariate analysis of each variable. Variables that had univariate test p-values <0.25 as well as known biologically or socially important variables were considered as candidate variables for the multivariable model. All potential variables were entered in the model. A reduced model was constructed by manually removing, one at a time, the variables with the highest non-significant p values ($p \geq 0.05$). The final model contained only the statistically significant variables or variables of established biologic importance.

4.3 Results

670 children and their parents or main care givers participated in the study. The response rate for anthropometric measurement and completion of questionnaires was 95.7%.

4.3.1 Socio-demographic characteristics

The proportion of boys (49.6%) and girls (50.4%) in the study was similar, and their mean age was 56.2 months (SD = 3.6). Children of Kinh ethnicity accounted for 83.9% of the sample and the remaining 15.1% were Chinese. There was a balanced distribution of boys and girls in each 6-month age group (Table 4-1). Table 4-1 also shows the distribution of parental education levels and occupations by gender. There was a similarity in distribution of parental education patterns in both genders. More than 50% of fathers completed high school or higher levels of education, with 37.5% completing high school and 16.6% completing college or university courses. The percentage of mothers, who completed high school or a higher education level, was greater than that for fathers but this difference was not significant. There were no significant differences in the distribution of parental occupation by gender. However, the percentage of fathers who worked as professionals or teachers was significantly higher than that for mothers. In contrast, about one third of mothers did house work or other work but only a small percentage of fathers were involved in this type of activity.

Table 4-1 Socio-demographic characteristics of children by gender

Socio-demographic characteristics of children aged 4 to 5 years by gender in urban areas of HCMC, 2005 (n=670)

Characteristic	Boys (N = 333)		Girls (N = 337)		Total (N = 670)	
	%	95% CI	%	95% CI	%	95% CI
Age in months						
48-53	37.9	30.2, 46.3	33.0	28.5, 37.8	35.4	31.1, 40.0
54-59	42.5	35.1, 50.3	46.5	40.8, 52.4	44.5	39.4, 50.0
60-65	19.6	15.9, 23.9	20.5	15.5, 26.6	20.0	17.0, 23.5
Ethnicity						
Kinh	85.1	71.4, 92.9	82.8	72.3, 89.9	83.9	72.3, 91.2
Chinese	14.9	7.1, 28.7	17.2	10.1, 27.7	16.1	8.7, 27.7
Parental education						
Paternal						
Primary school	9.3	4.9, 16.9	11.0	6.7, 17.5	10.2	6.2, 16.3
Secondary school	37.5	30.1, 45.5	33.9	27.3, 41.1	35.7	29.7, 42.2
High school	36.0	28.0, 44.9	39.1	32.9, 45.6	37.5	31.9, 43.6
College/University	17.2	11.7, 24.6	16.0	10.4, 23.8	16.6	11.4, 23.6
Maternal						
Primary school	5.8	2.4, 13.5	9.5	5.2, 16.7	7.6	3.9, 14.5
Secondary school	30.4	23.7, 38.1	26.1	20.0, 33.4	28.3	22.4, 34.9
High school	39.1	32.9, 45.8	41.4	35.5, 47.5	40.3	35.5, 45.2
College/University	24.7	19.2, 31.1	23.0	16.4, 31.3	23.9	18.3, 30.4
Parental Occupation						
Paternal						
Teacher/ Professionals	15.9	11.1, 22.3	15.8	11.9, 20.7	15.9	12.2, 20.4
Government officers	21.1	15.7, 27.7	19.2	13.9, 25.8	20.1	15.3, 26.0
Traders	5.3	3.0, 9.1	5.4	2.6, 10.8	5.3	3.1, 9.0
Small business/ Skilled workers	25.9	18.5, 35.0	27.8	21.9, 34.7	26.9	21.1, 33.6
Laborers/ Street or home trader	29.6	24.1, 35.8	30.2	23.4, 37.9	29.9	24.7, 35.7
Home maker/ Others	2.2	1.0, 4.5	1.6	0.7, 3.5	1.9	1.1, 3.2
Maternal						
Teacher/ Professionals	8.2	5.3, 12.4	6.6	4.0, 10.8	7.4	5.0, 10.8
Government officers	16.0	11.5, 21.9	17.3	12.1, 24.1	16.7	12.4, 22.0
Traders	2.9	1.4, 5.8	2.0	0.8, 5.0	2.4	1.4, 4.3
Small business/ Skilled workers	34.1	27.5, 41.4	34.2	28.1, 40.9	34.2	30.0, 38.8
Laborers/ Street or home trader	7.8	4.9, 12.1	8.0	5.0, 12.4	7.9	5.6, 11.0
Home maker/ Others	30.0	24.7, 38.1	31.8	24.2, 40.6	31.4	26.3, 37.1

4.3.2 Anthropometric characteristics

The average anthropometric measurements of the children by socio-demographic factors are shown in Table 4-2. The trends in both mean weight and height were observed across the three age groups in both genders. Boys were heavier and taller than girls in each age group. Thus, the mean BMI of boys was higher than that of girls; however, there was no significant difference in mean BMI by age. There were no significant differences in weight, height or BMI between Kinh and ethnic Chinese children in both genders. Children from households in the highest tertile of wealth index had higher mean weight, height, and BMI compared with those from households in the lowest wealth index tertile. However, there were no significant differences in mean weight, height and BMI in children across wealthy and less wealthy districts in both genders.

Table 4-2 Mean weight, height, and BMI by gender and socio-demographic characteristics.

Mean weight (kg), height (cm), and BMI (kg/m^2) of children aged 4 to 5 years, by gender and socio-demographic characteristics in urban areas of HCMC, 2005 (n=670).

Characteristic (n)	Weight (kg)				Height (cm)				BMI (kg/m^2)			
	Mean	SD	Median	p-value	Mean	SD	Median	p-value	Mean	SD	Median	p-value
Boys (n=333)												
Age in months												
48-53	19.3	3.7	18.5	0.000[1]	105.8	4.7	105.7	0.000[1]	17.1	2.2	16.6	0.802[1]
54-59	20.3	3.9	19.6		107.9	4.5	107.7		17.4	2.5	16.7	
60-65	21.2	4.2	21.2		110.2	4.9	110.4		17.3	2.4	17.3	
Ethnicity												
Kinh	20.2	4.1	19.5	0.120[2]	107.6	5.0	107.5	0.415[2]	17.3	2.4	16.8	0.148[2]
Chinese[3]	19.4	3.1	18.9		107.1	4.7	107.6		16.8	2.2	16.3	
Household wealth												
Poorest	19.5	4.4	18.9	0.056[1]	106.8	5.4	106.6	0.035[1]	17.0	2.6	16.2	0.127[1]
Middle	19.9	3.9	18.9		107.5	4.9	107.7		17.1	2.2	16.6	
Wealthiest	20.8	3.6	20.2		108.4	4.5	108.0		17.6	2.3	17.3	
Districts												
Wealthy	20.4	4.3	19.5	0.290[2]	108.2	5.6	107.9	0.066[2]	17.3	2.4	16.7	0.907[2]
Less wealthy	19.9	3.7	19.1		107.2	4.2	107.1		17.2	2.3	16.8	
Girls (n=337)												
Age												
48-53	18.0	2.9	18.1	0.000[1]	104.2	4.3	104.4	0.000[1]	16.5	1.9	16.1	0.620[1]
54-59	18.9	3.4	18.5		106.9	4.8	107.4		16.4	2.0	16.2	
60-65	20.4	3.3	20.2		109.7	4.1	110.3		16.9	2.1	16.5	
Ethnicity												
Kinh	19.0	3.4	18.7	0.563[2]	106.7	5.0	107.2	0.582[2]	16.6	2.1	16.3	0.751[2]
Chinese[3]	18.6	3.0	18.4		106.1	4.6	107.2		16.5	1.9	16.2	
Household wealth												
Poorest	18.4	2.9	17.9	0.001[1]	106	4.6	107.2	0.011[1]	16.3	1.8	16.0	0.002[1]
Moderate	18.6	3.4	18.2		106.2	5.1	106.5		16.4	2.0	16.1	
Wealthiest	19.9	3.3	19.8		107.7	4.7	107.7		17.1	2.1	17.0	
Districts												
Wealthy	19.3	3.3	18.9	0.120[2]	107.3	4.9	107.9	0.026[2]	16.6	2.0	16.5	0.597[2]
Less wealthy	18.7	3.3	18.0		106.2	4.8	105.8		16.5	2.1	16.0	

[1] *Means are significantly different between the first and the third groups, by Bonferroni test*

[2] *p value is calculated by Pearson chi-square test*

[3] *Two children of Thai ethnicity were included in the Chinese group*

Figure 4-1 shows the BMI Z-score distribution for boys is shifted further to the right than the distribution for girls, and very different from the distribution of BMI Z-scores in the reference population.

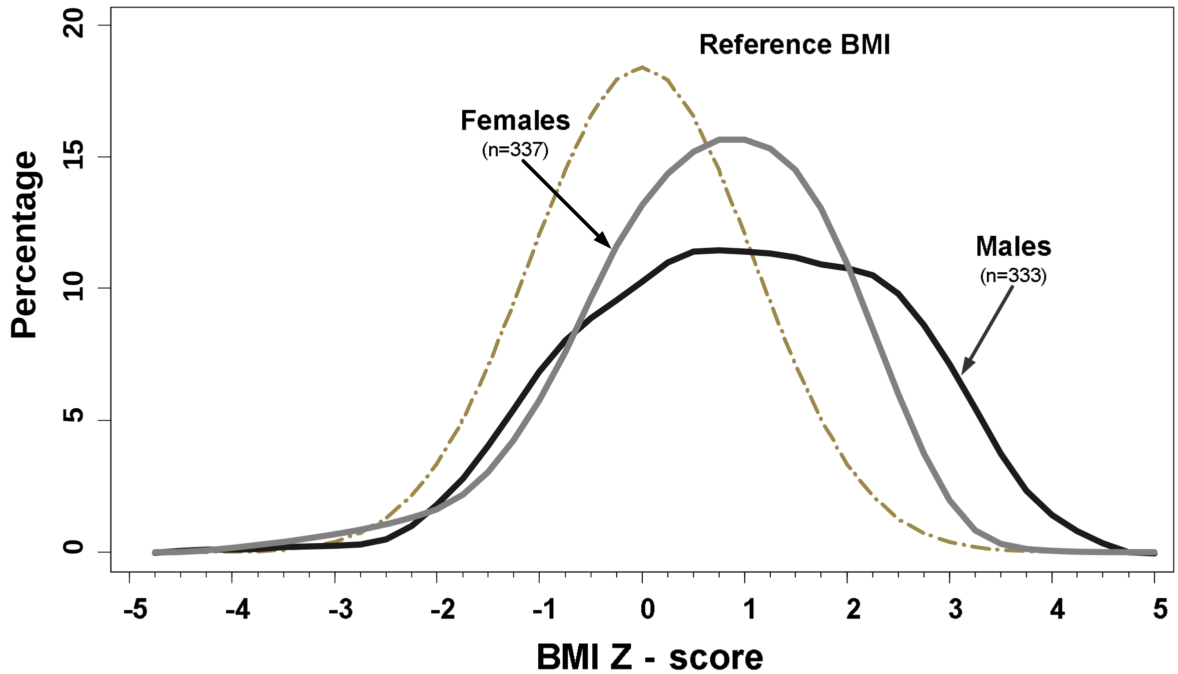


Figure 4-1 Plot of Lowes curves for the BMI-for-age Z score distributions by gender

Plot of Lowes curves for the BMI-for-age Z score distributions for children 4 to 5 years by gender in urban areas of HCMC, 2005, compared to the 2000 CDC growth reference (Kuczmarkski et al., 2000).

The BMI-for-age Z-score distribution curves for children from the wealthiest households have shifted to the right compared with those of children from the poorest households (Figure 4-2). This indicates that BMI distribution for children from the wealthiest group is positive skewer than BMI distribution for children from the poorest group. Also, the BMI Z-score distribution curve for children from the wealthiest households was above the CDC reference curve, indicating a population in HCMC with higher BMI than the reference population.

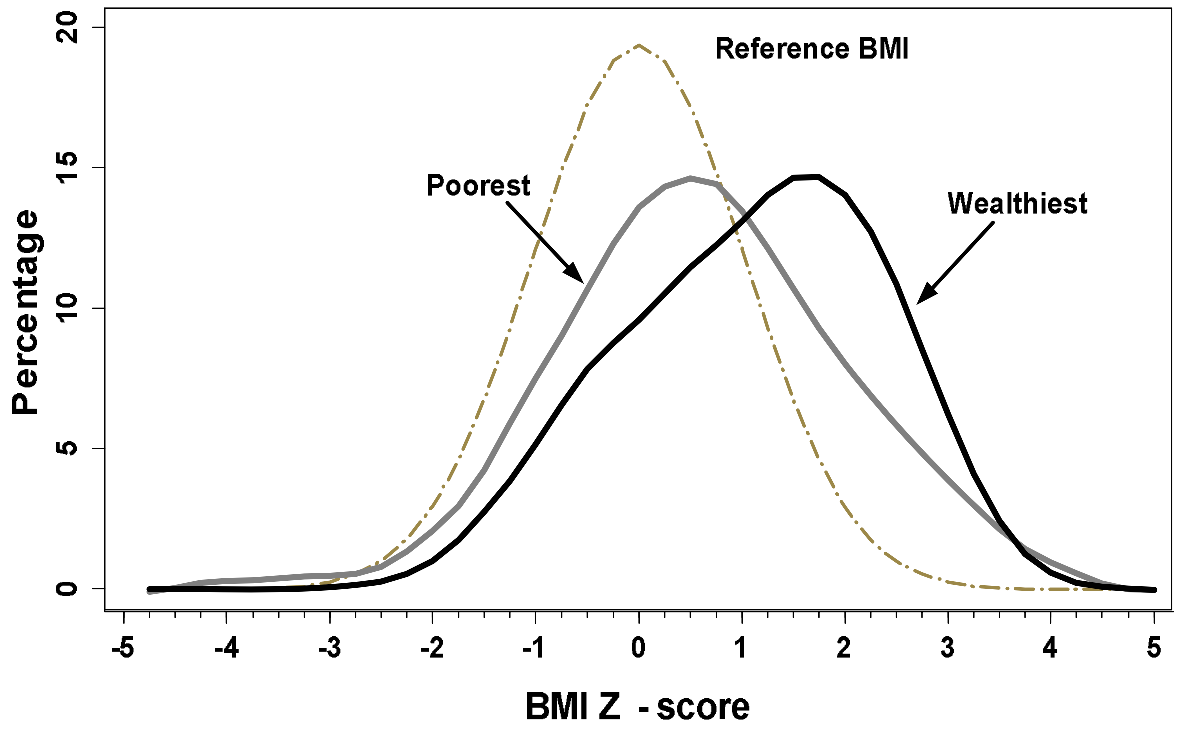


Figure 4-2 Plot of Lowes curves for the BMI-for-age Z score distributions by household wealth categories

Plot of Lowes curves for the BMI-for-age Z score distributions for children 4 to 5 years by household wealth categories in urban areas of HCMC, 2005, compared with the 2000 CDC growth reference (Kuczmarkski et al., 2000).

4.3.3 Overweight and obesity by socio-demographic factors

Table 4-3 shows the prevalence of overweight and obesity. There were no gender differences in the prevalence of overweight; however, the prevalence of obesity was significantly higher in boys than in girls ($p<0.05$). There were no differences in the prevalence of overweight and obesity by age in both genders. There was a similar prevalence of overweight and obesity among boys between the Kinh and Chinese ethnic groups, and across the three household wealth index groups. However, the prevalence of overweight among girls with Kinh's ethnic and from the wealthiest households was significantly higher compared with those with Chinese's ethnic and from the poorest households ($p=0.031$ and $p=0.002$ respectively).

Table 4-3 Prevalence of overweight by gender, socio-demographic characteristics

Percentage and 95% confidence intervals of overweight[1] in children aged 4 to 5 years by gender, socio-demographic characteristics, in urban areas of HCMC, 2005 (n=670)

Characteristic	Number	Overweight[1]			Obesity[1]		
		%	95% CI	p-value[2]	%	95% CI	p-value[2]
All	670	20.5	17.5, 24.3		16.3	13.2, 20.4	
Boys	333	19.1	15.7, 23.1	0.072	21.7	16.8, 27.5	0.000
Age in months							
48-53	123 (36.9)	16.3	10.5, 24.6	0.183	17.8	12.0, 25.7	0.498
54-59	144 (43.2)	19.1	13.8, 25.8		25.1	18.3, 33.5	
60-65	66 (19.8)	24.6	14.4, 38.9		21.6	13.0, 33.6	
Ethnicity							
Kinh	283 (85.0)	19.7	16.1, 23.8	0.182	22.5	16.9, 29.2	0.319
Chinese	50 (15.0)	16.0	9.2, 26.5		17.2	11.4, 25.0	
Household wealth							
Poorest	112 (33.6)	14.3	9.0, 22.0	0.074	21.5	14.7, 30.4	0.336
Middle	101 (30.3)	21.1	14.6, 29.5		15.9	10.2, 24.0	
Wealthiest	120 (36.1)	22.1	17.3, 27.7		26.7	18.6, 36.8	
Districts							
Wealthy districts	164 (49.3)	19.5	14.4, 25.9	0.740	20.1	14.9, 26.6	0.599
Less wealthy districts	169 (50.7)	18.9	14.9, 23.7		22.5	16.0, 30.6	
Girls	337	21.8	17.2, 27.1		11.0	6.4, 18.3	
Age in months							
48-53	109 (32.3)	22.7	15.5, 31.9	0.592	7.3	4.2, 12.4	0.179
54-59	158 (46.9)	21.4	16.0, 28.0		10.6	5.5, 19.4	
60-65	70 (20.8)	21.2	11.1, 36.6		18.1	8.3, 35.1	
Ethnicity							
Kinh	278 (82.5)	23.7	18.8, 29.4	0.031	11.2	6.3, 18.9	0.875
Chinese	59 (17.5)	12.6	8.1, 19.0		10.5	4.7, 21.8	
Household wealth							
Poorest	113 (33.5)	16.5	11.8, 22.6	0.002	8.8	3.9, 18.9	0.252
Middle	121 (35.9)	19.4	13.6, 26.9		10.2	4.4, 21.9	
Wealthiest	103 (30.6)	30.5	22.7, 39.0		14.6	8.3, 24.5	
Districts							
Wealthy districts	166 (49.3)	25.3	17.9, 34.5	0.178	12.1	6.5, 21.1	0.659
Less wealthy districts	171 (50.7)	19.9	14.8, 26.3		10.5	4.8, 21.4	

[1] *Overweight and obesity according to IOTF definition, overweight and obesity presented separately (Cole et al., 2000)*

[2] *p value is calculated by Pearson chi-square test*

4.3.4 Re-analysis of data from other studies on preschool obesity in HCMC using IOTF

Table 4.4 presents the prevalence of overweight/obesity from other cross-sectional studies conducted in preschoolers in HCMC, using similar definition for overweight as in the current study. The estimate of overweight/obesity in the present study was found to significantly be higher than in the 2002 survey (Hung et al, 2003) and the 2005 survey focusing on one urban district in HCMC (Hoa, 2005). Nevertheless, it is comparable to the 2005 survey carried out in four urban districts in HCMC (Nomura, 2005).

Table 4-4 Re-analysis of data from other studies on preschool obesity in HCMC using IOTF definition

Percentage and 95% confidence interval of overweight in preschool children from previous studies in HCMC using IOTF definition

Sources	Level	Number	Overweight/Obesity[1] (%)	95% CI
Hung et al, 2003	City	1780	22.0	20.1, 24.0
Hoa, 2005	Regional (1 out of 12 urban districts)	1242	27.8	24.8, 29.8
Nomura, 2005	Regional (4 out of 12 urban district)	738	43.9	40.3, 47.6

[1]Obesity according to IOTF definition (Cole et al, 2000)

4.3.5 Underweight, stunting and wasting

Table 4-5 presents the prevalence of underweight, stunting and wasting. There were no differences in underweight, stunting or wasting by gender, age groups, or household wealth index group and location of schools.

Table 4-5 Prevalence of underweight, stunting, and wasting

Percentage and 95% confidence intervals of underweight, stunting, and wasting[1] in children aged 4 to 5 years in urban areas of HCMC, 2005 (n = 670)

Characteristic	Underweight		Stunting		Wasting	
	%	95% CI	%	95% CI	%	95% CI
All (n = 670)	2.7	1.6, 4.4	2.3	1.4, 4.0	2.6	1.6, 4.8
Boys	2.8	1.4, 5.7	2.2	0.9, 5.3	3.6	1.8, 7.1
Age in months						
48-53	2.1	0.7, 6.4	3.7	1.6, 8.3	_	
54-59	2.3	0.7, 7.0	1.9	0.6, 5.9	2.8	1.0, 7.9
60-65	4.0	1.1, 13.2	1.1	0.2, 7.5	2.0	0.3, 12.8
Household wealth						
Poorest	6.4	3.6, 11.1	4.7	2.3, 9.4	4.1	1.3, 12.4
Moderate	1.3	0.2, 8.5	2.7	0.9, 8.1	0.7	0.01, 4.8
Wealthiest	_		_		_	
Districts						
Wealthy districts	1.8	0.7, 4.7	3.7	2.2, 6.1	3.7	2.2, 6.1
Less wealthy districts	3.0	1.2, 6.9	1.8	0.6, 4.9	1.8	0.6, 4.9
Girls	2.6	1.2, 5.3	2.4	1.3, 4.4	1.6	0.5, 4.8
Age in months						
48-53	3.1	1.1, 8.3	0.6	0.01, 4.5	2.4	0.7, 8.0
54-59	4.0	1.6, 9.5	3.4	1.1, 10.3	5.2	2.2, 11.7
60-65	_		1.9	0.2, 12.9	1.9	0.2, 12.9
Household wealth						
Poorest	3.0	0.9, 9.2	2.3	0.3, 14.8	1.9	0.4, 7.6
Moderate	5.1	2.4, 10.2	2.8	0.9, 8.1	6.0	3.1, 11.4
Wealthiest	_		1.3	0.2, 7.8	2.6	0.6, 10.2
Districts						
Wealthy districts	6	2.7, 12.9	1.8	0.4, 7.2	4.8	1.7, 13.2
Less wealthy districts	1.2	0.3, 4.3	2.3	0.8, 6.9	2.9	1.2, 7.0

[1]Underweight, stunting and wasting defined as weight for age, height for age and BMI Z scores < 5th percentile based on 2000 CDC Growth Reference (Kuczmarkski et al., 2000)

Table 4-6 shows the estimates of overweight and obesity by gender and age groups amongst children from 50 months to younger than or equal 60 months using two definitions. In general, the prevalence of overweight and obesity (combined) defined by IOTF criteria, was significantly higher than that classified by the new WHO standards 2006, being 35% and 23.3% respectively.

There were differences in the classification of overweight and obesity by gender between the two methods. The prevalence of overweight in girls using IOTF was double the figure obtained when using the new WHO 2006 growth standards (30.5% vs. 14.3%), while the percentage of overweight or obese boys was similar for both methods. The gender pattern was consistent for obesity rather than overweight for both methods. However, more boys and girls were likely to be classified as obese by IOTF than by the WHO 2006 growth standard. There was no gender difference in the prevalence of overweight using IOTF, but the prevalence of overweight in boys was close to being significantly higher than girls using the new WHO 2006 growth standard (20.6 vs. 12.5%). Comparisons of the prevalence of overweight and obesity (combined) between the methods across age group, showed different gender patterns by age. There was a different distribution of overweight by gender in the age group 49 to 54 months where there was a higher prevalence of overweight in girls than in boys using IOTF (26.3% vs. 15.8) but the opposite finding was observed when using WHO standards (10.7% vs.19.2%). There was a similar gender pattern in age group 55 to 60 months although gender differences were not significant and IOTF cut offs appeared to over-estimate overweight/obesity in comparison with the new WHO standards 2006.

Table 4-6 Prevalence of overweight and obesity, comparing the IOTF and the new WHO standards 2006 methods of classification

Percentage of overweight and obesity and 95% confidence interval by gender and age group in children aged 50 to ≤ 60 months, comparing the IOTF and WHO 2005 approaches of classification (n = 575)

Groups (n)	IOTF[1]			WHO[2]		
	Overweight Percentage 95% CI	Obese Percentage 95% CI	Combined Percentage 95% CI	Overweight Percentage 95% CI	Obese Percentage 95% CI	Combined Percentage 95% CI
All (n = 575)	19.8	15.2	35.0	16.5	6.8	23.3
	16.7, 23.3	11.9, 19.3	29.8, 40.6	13.0, 20.7	4.4, 10.4	18.7, 28.7
Boys (n = 285)	17.9	21.7	39.6	20.6	11.9	32.5
	14.1, 22.4	16.9, 27.5	33.1, 46.5	16.0, 26.0	7.3, 18.8	25.8, 39.9
Girls (n = 290)	21.7	8.8	30.5	12.5	1.8	14.3
	17.3, 26.8	4.8, 15.4	23.6, 38.4	8.7, 17.6	0.8, 4.3	9.8, 20.5
49-54 months						
Boys (n = 149)	15.8	17.0	32.8	19.2	9.2	28.4
	10.5, 23.0	12.2, 23.2	24.9, 41.7	13.2, 27.1	4.7, 17.3	19.8, 38.8
Girls (n = 148)	26.3	6.3	32.6	10.7	2.2	12.9
	19.6, 34.3	3.1, 12.1	24.5, 41.8	6.5, 17.2	0.7, 7.0	8.0, 20.2
55-60 months						
Boys (n = 136)	20.2	27.1	47.3	22.2	14.9	37.1
	15.1, 26.7	18.3, 38.0	37.9, 56.9	15.2, 31.1	7.9, 26.4	28.0, 47.2
Girls (n = 142)	16.8	11.5	28.3	14.4	1.4	15.8
	11.4, 24.1	5.7, 21.9	19.9, 38.4	8.0, 24.4	0.3, 6.4	8.9, 26.4

[1] Overweight and obesity according to IOTF definition (Cole et al., 2000)
[2] Overweight and obesity were defined by BMI > 2 SD & >3 SD according to WHO 2006 (WHO, 2006)

4.3.6 Risk factors for overweight and obesity

The effects of demographic and socioeconomic variables on the development of childhood obesity were analysed separately with two different outcomes: overweight (including obesity) and obesity alone. The findings from univariate and multivariate analyses for each outcome are presented in Tables 4-7 and 4-8.

As indicated in Table 4-7, univariate analyses demonstrated a significant association between overweight/obesity and children whose fathers attended high school or college/university, children whose fathers worked as professionals or teachers, children whose mothers were government officers, children for whom both parents had BMI ≥ 23 kg/m^2, and children who came from the wealthiest households. In contrast, children who had longer duration of breast-feeding and longer duration of sleeping at night had a significantly decreased risk of overweight and obesity.

Multivariate analysis showed that gender was not associated with overweight/obesity. The association between paternal education and overweight/obesity and obesity in children was found in those whose fathers had college or university levels of education with PR of 1.93 (95% CI: 1.25, 2.99) and 2.24 (95% CI: 1.10, 4.85) respectively. Maternal education was not associated with overweight/obesity after adjustment for other risk factors. Where both parents were overweight, children were 1.87 times (95% CI: 1.37, 2.54) more likely to be overweight/obese than those whose parents were of normal weight. Birth weight ≥ 4000 grams was significantly associated with overweight and obesity in children compared with a birth weight equal to or greater than 2500 grams and less than 3000 grams with PR of 1.52 (95% CI: 1.01, 2.32). The association between overweight/obesity and breast-feeding was not as strong as for obesity (Table 4-8). For each additional hour of sleep, children had a significant decrease of 13% (PR 0.87, 95% CI: 0.78, 0.98) in the odds of being overweight/obese. Note that gender, age, mother's education level, and parental occupation were also considered in the multivariate model for overweight/obesity, but were removed due to the lack of statistical significance.

Table 4-7 Factors associated with overweight or obesity in children aged 4 to 5 years in urban areas of HCMC, 2005

Factors	Number	Overweight/Obesity[1]			
		Unadjusted PR (95% CI)		Adjusted PR[2] (95% CI)	
Gender					
Girls	338	1.0		1.0	
Boys	332	1.24	(0.93, 1.66)	1.2	(0.89, 1.61)
Age in months					
48-53	231	1.0		_	
54-59	301	1.17	(0.93, 1.49)	_	
60-65	138	1.33	(0.93, 1.90)	_	
Paternal education					
Primary	49	1.0		1.0	
Secondary	178	1.54	(0.90, 2.63)	1.43	(0.89, 2.30)
High school	272	2.06	(1.27, 3.33)	1.81	(1.16, 2.82)
College/ University	167	2.4	(1.54, 3.72)	1.93	(1.25, 2.99)
Maternal education					
Primary	66	1.0		_	
Secondary	227	1.19	(0.73, 1.93)	_	
High school	257	1.42	(0.85, 2.35)	_	
College/ University	118	1.58	(0.99, 2.53)	_	
Paternal occupation					
Laborer/ Street or home trader	194	1.0		_	
Traders	38	1.14	(0.65, 2.00)	_	
Home maker/ Others	13	1.36	(0.64, 2.88)	_	
Small business/ Skilled workers	176	1.45	(1.16, 1.80)	_	
Government officers	137	1.48	(0.98, 2.21)	_	
Teacher/ Professionals	109	1.79	(1.41, 2.28)	_	
Maternal occupation					
Laborer/ Street or home trader	54	1.0		_	
Traders	19	1.57	(0.57, 4.30)	_	
Home maker/ Others	204	1.58	(0.95, 2.62)	_	
Small business/ Skilled workers	221	1.37	(0.67, 2.79)	_	
Government officers	117	1.98	(1.15, 3.43)	_	
Teacher/ Professionals	53	1.45	(0.76, 2.78)	_	
Parental BMI status[3]					
No parents overweight	314	1.0		1.0	
Father only overweight	209	1.27	(0.89, 1.81)	1.15	(0.82, 1.62)
Mother only overweight	62	0.85	(0.51, 1.43)	0.87	(0.58, 1.31)
Both parents overweight	65	1.96	(1.47, 2.62)	1.87	(1.37, 2.54)
Household wealth index					
Poorest	225	1.0		1.0	
Moderate	222	1.08	(0.84, 1.38)	1.04	(0.79, 1.36)
Wealthiest	223	1.54	(1.15, 2.06)	1.28	(0.96, 1.70)
Birth weight (grams)					
2500 - 2999	171	1.0		1.0	
<2500	32	0.52	(0.19, 1.39)	0.5	(0.18, 1.36)
3000 - 3999	433	1.11	(0.94, 1.32)	1.0	(0.81, 1.24)
≥ 4000	25	1.66	(1.05, 2.61)	1.52	(1.01, 2.32)
Duration of breast feeding (months)		0.99	(0.97, 1.00)	0.98	(0.97, 1.00)
Duration of sleeping (hours)		0.85	(0.78, 0.94)	0.87	(0.78, 0.98)

[1]Overweight and obesity according to IOTF definitions (Cole et al., 2000)
[2] Adjusted prevalence ratio and 95% CIs were calculated with multivariate Poisson regression analysis
[3] Overweight in parents defined as BMI ≥ 23 (Corazon et al., 2004)

With obesity as the outcome, univariate analyses indicated that gender, paternal education, parental overweight status, birth weight, duration of breast-feeding, and sleep duration were all significantly associated with obesity (Table 4-8). Multivariate analysis has revealed that boys were 1.91 times (95% CI: 1.06, 3.45) more likely than girls to be obese. A similar association was found for parental overweight and obesity to overweight/obesity in children where PR of being obese for children with both parents overweight, was 2.59 (95% CI: 1.46, 4.61) higher than for those whose parents were of normal weight. The prediction of obesity in children who had high birth weight ($\geq$ 4000 grams) compared with those who had a birth weight equal to or greater than 2500 grams and less than 3000 grams, was stronger than that for predicting overweight/obese with PR of 1.99 (95% CI: 1.13, 3.51). The protective associations between breast feeding and sleep hours at night were even stronger for obesity than for overweight/obesity. The PR of being obese significantly decreased by 5% (PR 0.95, 95% CI: 0.93, 0.98) for each additional month of breast-feeding and a significant decrease of 25% (PR: 0.75, 95% CI: 0.60, 0.94) in developing obesity for each additional hour of sleep. The age, maternal education level, and parental occupation were also considered in the multivariate model for obesity, but were removed due to the lack of statistical significance.

Table 4-8 Factors associated with obesity in children aged 4 to 5 years in urban areas of HCMC, 2005

Factors	Number	Obesity[1]			
		Unadjusted PR (95% CI)		Adjusted PR[2] (95% CI)	
Gender					
Girls	338	1.0		1.0	
Boys	332	1.96	(1.05, 3.65)	1.91	(1.06, 3.45)
Age in months					
48-53	231	1.0		_	
54-59	301	1.35	(0.90, 2.06)	_	
60-65	138	1.54	(0.90, 2.62)	_	
Paternal education					
Primary	49	1.0		1.0	
Secondary	178	1.55	(0.69, 3.46)	1.54	(0.71, 3.32)
High school	272	1.9	(0.82, 4.39)	1.97	(0.86, 4.54)
College/ University	167	2.29	(1.19, 4.41)	2.24	(1.04, 4.85)
Maternal education					
Primary	66	1.0		_	
Secondary	227	1.17	(0.57, 2.41)	_	
High school	257	1.55	(0.71, 3.42)	_	
College/ University	118	1.89	(0.84, 4.25)	_	
Paternal occupation					
Laborer/ Street or home trader	194	1.0		_	
Traders	38	0.55	(0.21, 2.16)	_	
Home maker/ Others	13	1.42	(0.46, 4.34)	_	
Small business/ Skilled workers	176	1.23	(0.79, 1.92)	_	
Government officers	137	1.21	(0.62, 2.36)	_	
Teacher/ Professionals	109	1.31	(0.68, 2.53)	_	
Maternal occupation					
Laborer/ Street or home trader	54	1.0		_	
Traders	19	0.84	(0.09, 8.21)	_	
Home maker/ Others	204	1.53	(0.59, 3.97)	_	
Small business/ Skilled workers	221	1.71	(0.52, 5.61)	_	
Government officers	117	1.76	(0.58, 5.39)	_	
Teacher/ Professionals	53	1.82	(0.64, 5.14)	_	
Parental BMI status[3]					
No parents overweight	314	1.0		1.0	
Father only overweight	209	1.59	(0.85, 2.98)	1.49	(0.82, 2.73)
Mother only overweight	62	1.5	(0.75, 2.98)	1.49	(0.76, 2.95)
Both parents overweight	65	2.59	(1.46, 4.61)	2.38	(1.35, 4.20)
Household wealth index					
Poorest	225	1.0		1.0	
Moderate	222	0.84	(0.49, 1.42)	0.76	(0.47, 1.25)
Wealthiest	223	1.39	(0.86, 2.25)	1.0	(0.69, 1.46)
Birth weight (grams)					
2500 - 2999	171	1.0		1.0	
<2500	32	0.68	(0.17, 2.78)	0.64	(0.16, 2.62)
3000 - 3999	433	1.38	(0.91, 2.10)	1.16	(0.82, 1.63)
≥ 4000	25	2.56	(1.39, 4.72)	1.99	(1.13, 3.51)
Duration of breast feeding (months)		0.96	(0.93, 0.99)	0.95	(0.93, 0.98)
Duration of sleeping (hours)		0.72	(0.59, 0.87)	0.75	(0.60, 0.94)

[1] Obesity according to IOTF definitions (Cole et al., 2000)

[2] Adjusted prevalence ratio and 95% CIs were calculated with multivariate Poisson regression analysis

[3] Overweight in parents defined as BMI ≥ 23 (Corazon et al., 2004)

4.4 Discussion

This is the first study to report the prevalence of overweight and obesity in a representative sample of children aged four to five years in urban areas of Ho Chi Minh City using the IOTF definitions for overweight and obesity. The findings reveal a substantial obesity epidemic in young children in kindergartens in the largest city in Vietnam. The prevalence of overweight and obesity was 20.5% (95% CI: 17.5, 24.3) and 16.3% (95% CI: 13.2, 20.4) respectively. In particular, the estimates for overweight and obesity amongst children younger than or equal to 60 months were high irrespective of which classification system was used, IOTF or WHO 2006 growth standard, although there were a number of differences between these two definitions. The widespread distribution of overweight and obesity in these children across households, irrespective of their wealth index, suggests that the childhood obesity epidemic in HCMC is no longer restricted to wealthy households, as reported for adolescents (Hong, 2005). However, as with adolescents, there is more obesity in males than females.

Most previous studies of overweight and obesity in preschool children in HCMC were conducted in selected urban districts of HCMC only and used weight-for-height as an indicator of adiposity rather than body mass index (Hung et al., 2003, Vu et al., 2005, Hoa, 2005, Nomura et al., 2005). In this study, data from previous studies were re-analysed using the IOTF definitions for overweight and obesity, thus allowing a direct comparison.

In a cross sectional study of nutritional status of children in kindergartens from HCMC in 2002, the prevalence of overweight and obesity for urban children with similar age was 22.0% (Hung et al., 2003). Using the same methods and age group, the re-analysis of the 2005 cross sectional study conducted in kindergartens from one of the twelve urban districts of HCMC (Hoa, 2005), revealed that the prevalence of overweight and obesity was 27.8%. Similarly re-analysis of another study in 2005 of children in kindergarten from four of the twelve urban districts of HCMC revealed the prevalence of overweight/obesity was 43.9% (Nomura et al., 2005). These findings indicate a recent, rapid increase in overweight and obesity in children in kindergartens in HCMC and the results of the other studies conducted in 2005 support this study's findings. Overweight and obesity has become an important public health problem in preschool aged children in urban areas of HCMC.

Comparisons of the findings reported here with studies from other Asian countries are difficult because of the variety of indicators and growth references used in other studies, and the paucity of recent surveys. The best comparison is with China. A substantial increase in overweight and obesity, (based on the IOTF definition), from 14.6% in 1989, to 28.9% in 1997, has been observed in children aged 2 to 6 years from urban areas , , with a similar increase in obesity from 1.5% in 1989, to 12.6% in 1997 (Luo and Hu, 2002). If these trends have continued in China, then the levels of overweight and obesity in preschool aged children in urban China should be similar to those observed in the same age group in HCMC in 2005 for this study. There are no other reports of the prevalence of overweight and obesity in preschool children in Asia using IOTF definitions. In Thailand, a cross sectional study using the weight for height index with the Thai national standard in 1997, reported that the prevalence of overweight among preschool children was 22.7% in urban areas (Sakamoto et al., 2001). The different indicators and growth references preclude meaningful comparisons with data from this study.

There were only 2.7% of children suffering from underweight (weight for age Z-score<5th percentile) in this study, indicating that there has been a large shift in nutritional status in this population in HCMC. Malnutrition in children was a serious health problem in the 1980s and 1990s. Previous reports have revealed that a "nutrition transition" has taken place in children and adolescents in recent years. The 2002 cross sectional study on nutritional status among preschoolers reported the proportion of underweight four to five year old children in urban areas (2.8% defined as weight for age index < -2 SD based on the 1978 WHO reference) was about one quarter of that for overweight children (12.1% defined as weight for height index > +2 SD based 1978 WHO reference) (Hung et al., 2003). Another cross sectional study on nutritional status in adolescents in urban areas of HCMC in 2004 has shown that the prevalence of underweight was 6.7% (defined as a BMI Z score derived from the CDC growth reference <-2SD) and was much lower than overweight/obesity (13.7%, overweight/obesity defined using IOTF reference) (Hong, 2005). This phenomenon is similar to that observed in other Asian countries such as Thailand, Malaysia, and China (Popkin, 1994, 2001).

Rapid socio-economic development and industrialization have produced changes in lifestyle in Asian countries. The diet has shifted to high energy density foods, physical activity has decreased and sedentary behaviour has become more common (Popkin, 1994, 2001, 2002b). Thus, rapid changes in health related behaviour and the environment may have contributed to the development of obesity in children during the recent past, in urban areas of HCMC. In 2004, adolescents from urban HCMC had diets that were higher in energy, protein, fat, and carbohydrate, and higher levels of sedentary behaviour than adolescents from rural areas of HCMC (Hong, 2005). The environment in urban areas has promoted physical inactivity and higher consumption of energy dense foods compared with rural areas (Hong, 2005). However, findings from this study have shown that the change in the prevalence of underweight (2.7% versus 6.7%) was lower in adolescent study (Hong, 2005), but the change in the prevalence of overweight/obesity (36.8% versus 13.7%) was higher in the preschool child study presented in this thesis. This suggests that the “nutrition transition” was more advanced in younger children than in older children in HCMC. Childhood obesity has not been considered an important health issue in developing countries, such as Vietnam. The reality of this health problem is now evident and requires urgent action.

The definitions of both the IOTF and the new WHO 2006 growth standard have revealed high incidence of overweight and obesity in children aged 48 to 60 months in urban areas of HCMC. However, the IOTF method overestimates the prevalence of overweight and obesity in children from 50 months to younger than or equal to 60 months, but more for girls than for boys, compared with the new WHO standard. The different reference populations used to construct the growth curves for these two methods and the different cut-off points used to classify overweight and obesity, may underlie these differences. The IOTF method has used international population-based references by pooling data from six large nationally representative cross sectional surveys in which the characteristics of the subjects and selective criteria for a reference population were not homogeneous across these data (Cole et al., 2000). The international reference population used for the WHO 2006 growth standard was purposely designed to produce a standard in which the children were raised in the optimal living conditions for normal growth development, and where their mothers followed healthy practices including breastfeeding and not smoking (WHO, 2006).

Although the IOTF cut-off points allow for international comparisons, there are some limitations with these cut-off points in defining overweight and obesity. The adult linked cut-offs of 25 kg/m^2 for overweight and 30 kg/m^2 for obesity could result in imposed differences in prevalence between boys and girls because of the lack of continuity with the adult definitions of overweight and obesity (Chinn and Rona, 2002). In addition, the selection of age 18 at which to define the percentile or Z-score cut-off points for overweight and obesity passing through BMI 25 kg/m^2 and BMI 30 kg/m^2 , may not be appropriate for use in situations where an increase in BMI has continued beyond 18 years as in UK and French populations (Chinn and Rona, 2002). However, the new WHO standards is limited in use for children younger than or equal to 60 months as there is no international growth standard for older children and adolescents.

The multivariate analyses revealed parental overweight was an important factor associated with overweight and obesity in preschool children (Table 4-7 & 4-8). A number of studies conducted in both developing and developed countries have also reported that overweight parents were a significant predictor for the development of overweight in their offspring, especially when both parents were obese (Whitaker et al., 1997, Danielzik et al., 2002, Zaimin et al., 2002, Hong, 2005, Ming, 2006). It has been suggested that family factors may have an impact on childhood obesity that is explained not only by genetics factors, but also by family dietary habits, food intake, and lifestyle including physical activity and interest in exercise (Jana and Andrew, 2001a). Aspects of the family environment may provide a context for the expression of genetic factors to produce familial patterns of overweight (Cutting et al., 1999).

The role of breast feeding in protecting children against overweight is unclear. A systematic review has indicated that breast feeding has a small but consistent protective effect against obesity in children (Arenz et al., 2004). Several longitudinal studies have confirmed this finding (Armstrong and Reilly, 2002, Burke et al., 2005). However, some cohort studies have concluded that breast feeding was not associated with later adiposity in children (Burdette et al., 2006, Parsons, 2006). In the present study, longer duration of breast feeding appeared to have a stronger effect on obesity than on overweight, irrespective of whether breastfeeding was treated as a continuous or a categorical variable. However, the protective effect of breast feeding against overweight/obesity was more easily demonstrated with breast feeding as a continuous variable measured in months rather than in categories of 6 months duration. As the causal relationship cannot be confirmed in this cross sectional study, the effect of breast feeding on later adiposity is more adequately examined in the analysis of the longitudinal data and is presented in Chapter 8.

Higher birth weight (≥ 4000 grams) was found to be associated with both overweight and obesity (Table 4). A number of earlier studies (Parsons et al., 1999, Armstrong and Reilly, 2002, Burke et al., 2005, Burdette et al., 2006, Parsons, 2006), have reported an association between birth weight and weight status of preschool aged children due to prenatal influences as well as genetic factors. Furthermore children who were overweight at the age 5 to 7 years often were reported to have had a high birth weight (Reilly et al., 2005, Parsons, 2006). In contrast, a number of studies have documented the link between small size at birth with accumulation of excess central fatness, leading to the hypothesis of foetal programming for later excess weight (Garnett et al., 2001, Yajnik, 2004a, Ong, 2006, Rogers, 2003). However, the cross-sectional analysis in the present study has found a large size at birth rather than small size as a risk factor for being obese, although caution should be made when interpreting the finding as there were only a small number of children with birth weight>4000g.

Several studies have reported that less sleep is associated with childhood obesity (Sekine et al., 2002, von Kries et al., 2002, Reilly et al., 2005). In this study, children with more hours of sleep per night had a lower risk of being overweight and obese, than children who had fewer hours of sleep at night. A number of hypotheses have been proposed as causal mechanisms for the association between less sleep and childhood obesity. Growth hormone, an anabolic hormone that is important for maintaining lipolysis during the night, is markedly decreased in the absence of sleep (Boyle et al., 1992). Lack of sleep may be associated with TV viewing or playing video games (Owens et al., 1999) and may lead to daytime sleepiness, somatic and cognitive problems, and a subsequent decrease in physical activity (Dinges et al., 1997). Thus, sleep may have an effect on energy balance. It has been suggested that the effect of sleep should be taken into account in preventing childhood obesity. Even small changes in energy balance are beneficial, although the precise mechanism for the relationship between short duration of sleep and obesity needs further examination (Taheri, 2006).

An important negative finding of this study was the lack of association between household wealth index and overweight/obesity or obesity although a higher PR of being overweight/obese in children whose fathers had higher education was observed. This differed from the results reported in a study on nutritional status of adolescents in urban areas of HCMC in 2004 in which the risk of being overweight/obese in adolescents from higher economic status families, was significantly higher than those from lower economic status families (Hong, 2005). Previous studies on childhood overweight in Asia have reported that higher socio-economic status is associated with childhood obesity in contrast with developed countries, where lower socio-economic status is often associated with childhood obesity (Sakamoto et al., 2001, Ming et al., 2006). Unlike studies in other countries that have reported a postitive association between SES and an increased risk of being obese, the negative findings in this study may imply the differences between lowest and the highest tertiles of household wealth index may not be very great. Thus the distribution of SES in this studied population may relatively narrow compared with populations in other studies. Furthermore, they also suggest that overweight/obesity of preschool children has spread across all socio-economic groups in HCMC.

There are three main limitations that should be considered when interpreting the findings of this study. Firstly, selection bias could be an important issue, since this study was conducted in kindergartens. The Department of Education in HCMC has reported kindergarten attendance of children aged four to five years at greater than 80%. The remaining 20% of children in this age group do not attend kindergarten and therefore were not available for recruitment for this study. These children may be from less wealthy families and have lower BMI than in the study population. Thus, generalization of our findings should be limited to preschool children attending kindergartens in urban areas of HCMC. Further work is needed to assess if there are important differences in BMI status in the children not attending kindergarten.

Secondly, self-reported, rather than measured, parental weight and height was used in the analyses. However, self-reported weight and height is known to result in underestimated BMI compared with BMI derived from measured weight and height (Wardle et al., 2001).

Such under-reporting of BMI may lead to some non-differential misclassification and reduced associations between parental BMI and childhood overweight and obesity. The association between parental BMI status and childhood overweight and obesity may also have been reduced if the under-reporting was greater with overweight and obese parents. The effect of this bias cannot be measured in this study. There also appears to have been some gender differences in under-reporting with more under-reporting by women (Table 3-4). This may have reduced the associations between maternal BMI status and childhood overweight and obesity.

Finally, since this was a cross sectional study, the causal relationships between the outcome and risk factors cannot be established because of the lack of a time dimension. Thus the findings about the association between parental BMI, breast feeding, birth weight, sleep hours, and overweight in children will be examined again, using the longitudinal data and will be presented in Chapter 8.

In summary, this study found that overweight and obesity is a serious public health problem in urban areas of Ho Chi Minh City regardless of whether the IOTF or the new WHO 2006 growth standard is used. The problem of overweight in young children appears to have become widespread in the city and is no longer restricted to wealthy households. Overweight and obesity in these preschool aged children was strongly associated with parental overweight, shorter duration of breast-feeding, fewer hours of sleep, and high birth weight. While these findings will be further assessed in a longitudinal cohort analyses (see Chapter 8), the picture emerging from this study is of a well established epidemic of obesity in these young children that needs urgent action.

Chapter 5 Trends in overweight and obesity

5.1 Introduction

It has been proposed that the rate of change in patterns of behaviour including diet and physical activity, and the prevalence of overweight in the developing world today is faster than the rate observed earlier in developed countries such as the United States or Europe (Popkin, 2002a, b). Rapid socio-economic development and urbanization may be important determinants not only for these changes but also for the changes in disease patterns in the developing world whereby infectious diseases and malnutrition decrease and over-nutrition and its complications increase (Popkin, 2002a, Popkin and Gordon-Larsen, 2004, Ulla et al., 2002). Health policies in most developing countries focused mainly on tackling under-nutrition and infectious diseases. Emphasis should be given to the adjustment of policy to deal with the increase in over-nutrition and other chronic diseases (Popkin, 2003, Popkin and Gordon-Larsen, 2004, Mendez and Popkin, 2004).

As mentioned in Chapters 2 and 4, the economic situation in Vietnam during the past two decades has improved considerably, especially in Ho Chi Minh City, which is an economic and trade centre for southern Vietnam and has the highest rate of economic development in the country. Until the end of the 1990s, overweight and obesity in children was not thought to be a major public health problem in Vietnam, including HCMC. But more attention has been focused on this health issue since the changes in lifestyle and disease patterns in the adult populations became apparent (Khoi, 1996, Loan and Hung, 2002). At present, there is enough evidence to assert that the child population in the urban areas of HCMC is undergoing a “nutrition transition” similar to that observed in neighbouring countries such as Thailand, Malaysia, and China (Kosulwat, 2002, Noor, 2002, Popkin, 2003). However, the pace at which overweight and obesity has emerged in child populations in Vietnam has not been examined, except for one study on adolescents (Hong, 2005). In order to design appropriate interventions to cope with this health issue, it is necessary to carefully monitor the time trends in overweight and obesity in child populations. This chapter aims to assess trends in the prevalence of overweight and obesity as well as in weight, height, and BMI distributions among children aged four to five years based on two cross sectional studies carried out in 2002 and 2005 in kindergartens in urban areas of HCMC.

5.2 Methodology

The trends in overweight and obesity were examined using data from a cross sectional studies of children aged four to five years in HCMC in 2002 and 2005. The survey in 2005 was the baseline measurement for a follow-up study which is presented in Chapter 3 of this thesis.

In the analyses presented in this chapter, the sample of the 2002 survey (Hung et al., 2003) was limited to children aged four to five years living in the urban areas in order to allow a valid comparison of the prevalence of overweight and obesity amongst children of the same age in 2002 and 2005. Thus, the restricted sample from the 2002 survey data is summarized as in the table below:

Table 5-1 Data structure of the 2002 cross sectional study and restricted data for trend analysis

Stage	Unit sampled	Number of units sampled	Sampling method	Frame	Restricted sample of children aged 4 to 5 years in the urban areas
1	Kindergartens	60 schools	PPS (population size of kindergarten)	List of kindergartens by urban district	39
2	Children aged 1 to 6 years olds	30 per school	Systematic random sampling	List of children prepared for each selected school	492

The 2005 baseline study also used multistage cluster sampling with two stages but with stratification by groups of districts (wealthy and less wealthy districts) in the first stage. Twenty kindergartens were selected in the first stage using a PPS method based on a frame of all kindergartens in urban areas of HCMC. In the second stage, 35 children aged four to five years were recruited from a prepared list of all children of similar age in each selected school using systematic random sampling. There were 670 children aged four to five years, and their parents, participating in these measurements. Details of the methods for this study were presented in Chapter 3.

Statistical analysis

Anthropometric analysis

BMI (kg/m^2) in children was calculated, and the age and gender specific BMI cut-off points recommended by the International Obesity Task Force (Cole et al., 2000) were used to define overweight and obesity among children age four to five years in the two studies. The weight for age z-scores, height for age z-scores and BMI z-scores were calculated based on the 2000 CDC Growth Reference (Kuczmarkski et al., 2000). The 5th percentile was the cut-off point used to classify underweight, stunting and wasting in this child population.

The overweight status of parents in both studies was assessed based on the BMI calculated from self-reported weight and height using the cut-off points of 23 kg/m^2 recommended for Asian populations (Corazon et al., 2004).

Adjustment for sampling design in both studies

Stata "svyset" commands, which use Taylor linearized variance estimation, adjusted the analyses for the cluster sampling design in both studies. Details of the "svyset" commands used in the 2005 study are described in Chapter 4. The following "svyset" command was used to adjust for the sampling design of the 2002 study:

```
svyset school [pw=pw], strata(strata) fpc(Nchildren_stratum) || Child_ID,
fpc(Nchildren)
```

where:

"`school`" is a variable to identify the kindergartens sampled for this study referred to as the primary sampling units

"`pw`" is a variable to weight the results based on the population size of children aged four to five years in 2002 of each strata in stage one

"`strata`" is an indicator variable for the strata in stage one

"`Nchildren_stratum`" is the total number of children aged four to five years in each stratum which serves as a finite population correction (fpc) factor for the sampling in each stratum

"`Child_ID`" is a variable to identify each child selected in each kindergarten

"`Nchildren`" is the total number of children in each selected kindergarten in stage one which serves as a finite population correction (fpc) factor for the sampling in each school.

Thus, the estimates for each study were weighted based on the child population in the kindergartens from wealthy versus less wealthy urban areas. Calculation of the sampling weights is described in detail in Chapter 3. The sampling weights for each stratum calculated for use in the 2002 were presented in Table 3-5 in Chapter 3.

The distribution of weight, height and BMI were described by mean and standard deviation by demographic groups for each study. The prevalence of overweight, obesity, and underweight together with their 95% confidence intervals were calculated across socio-demographic groups.

Using two tailed significance tests, categorical data were tested with Pearson chi-square tests, while normally distributed continuous data were tested with Student's t-tests. To test for the trends in the prevalence of overweight and obesity from 2002 to 2005, logistic regression was used with year of survey as predictor in the models adjusting for age, gender, parental overweight status and parental education level.

In addition, the frequency of children in narrow ranges of BMI-for-age Z-scores from the CDC 2000 Growth Reference were plotted and smoothed with a Lowes function to construct BMI Z-score frequency distribution curves assessing the trends in BMI Z-scores between the two studies (Chambers et al., 1983).

5.3 Results

Overall, there were 492 children aged four to five years in the 2002 survey (Hung et al., 2003) with the proportion of boys about 10% points higher than girls (55.9% and 44.1 respectively). The gender distribution of the 670 children participating in the 2005 study was approximately equal (49.7% boys and 50.3% girls).

The characteristics of children including age, gender, birth weight, weight, height, BMI and parental BMI in the two surveys are presented in Table 5-2. In general, children of both genders in the 2002 survey were approximately 1 to 1.5 months older than the children in the 2005 survey ($p<0.05$). However, children of both genders in 2005, were heavier at birth than children in the 2002 survey ($p<0.05$). Also, the mean weight of children of both genders has significantly increased from 2002 to 2005 ($p<0.001$) while the mean height has not changed significantly ($p = 0.2495$ for boys and $p= 0.1235$ for girls). Thus, mean BMI of children of both genders significantly changed over the three years ($p <0.001$). There was no significant difference in mean parental BMI for boys ($p = 0.5018$) or girls ($p = 0.4305$).

Table 5-2 Characteristics of children aged 4 to 5 years by gender in the 2002 and 2005 surveys

Means and standard deviations of birth weight, weight, height, BMI and parental BMI by gender in the 2002 & 2005 surveys

Characteristics	Survey 2002 (n = 492)		Survey 2005 (n = 670)		p-value[1]
	Mean	95% CI	Mean	95% CI	
Boys					
Birth weight (grams)	3126.7	3070.1, 3183.3	3197.9	3147.0, 3248.8	0.0317
Weight (kg)	18.7	18.1, 19.3	20.1	19.5, 20.7	0.0000
Height (cm)	107.2	106.3, 108.0	107.6	106.9, 108.2	0.2495
BMI (kg/m²)	16.2	15.9, 16.5	17.2	16.9, 17.6	0.0000
Paternal BMI	22.4	22.1, 22.8	22.2	21.8, 22.6	0.5018
Maternal BMI	21.0	20.6, 21.4	21.0	20.6, 21.3	0.9198
Girls					
Birth weight (grams)	3042.2	2998.0, 3086.5	3118.4	3067.8, 3169.1	0.0289
Weight (kg)	17.7	17.3, 18.1	18.9	18.3, 19.5	0.0000
Height (cm)	106.1	105.5, 106.8	106.6	105.9, 107.3	0.1235
BMI (kg/m²)	15.6	15.3, 15.9	16.6	16.2, 16.9	0.0000
Paternal BMI	22.4	22.0, 22.7	22.5	22.2, 22.8	0.4305
Maternal BMI	20.7	20.5, 21.0	21.1	20.8, 21.5	0.0699

[1] *p-value was calculated from Student's t-test*

The trend in the mean weight for children is shown in Figure 5-1. It can be seen that the mean weight for boys was always heavier than that for girls in the two surveys and it has significantly increased over the 3-year period from 18.7 kg to 20.1 kg for boys ($p<0.001$) and 17.7 kg to 18.9 kg for girls ($p<0.001$).

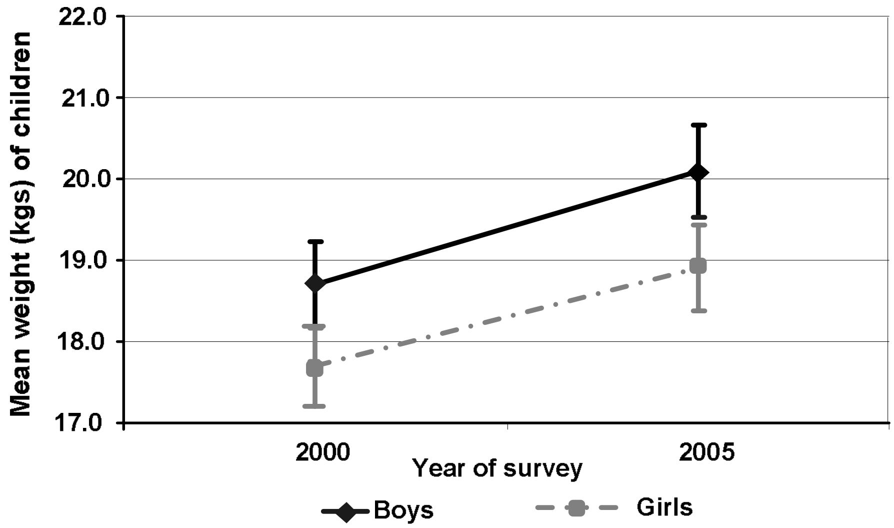


Figure 5-1 Trends in mean weight for children aged 4 to 5 years from 2002 to 2005
Mean weights and 95% confidence intervals for children in the 2002 and 2005 surveys

The mean height of children for both genders has increased over the three years from 107.2 cm to 107.6 cm for boys, and 106.1 cm (p=0.2495) to 106.6 cm for girls (p=0.1235), but these differences were not significant (Figure 5-2).

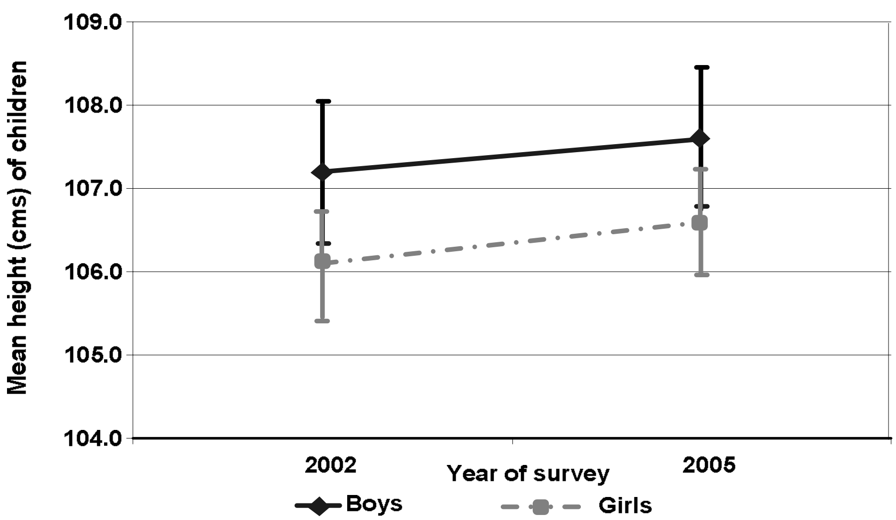


Figure 5-2 Trends in mean height for children aged 4 to 5 years from 2002 to 2005
Mean heights and 95% confidence intervals for children in the 2002 and 2005 surveys

Figure 5-3 shows that the mean BMI for boys is higher than for girls in both surveys. Also, the mean BMI for boys and girls has increased significantly over the three year period with the speed of this increase over time being similar for both genders when BMI increased significantly from 16.2 kg/m^2 to 17.2 kg/m^2 for boys ($p<0.001$) and 15.6 kg/m^2 to 16.6 kg/m^2 for girls ($p<0.001$).

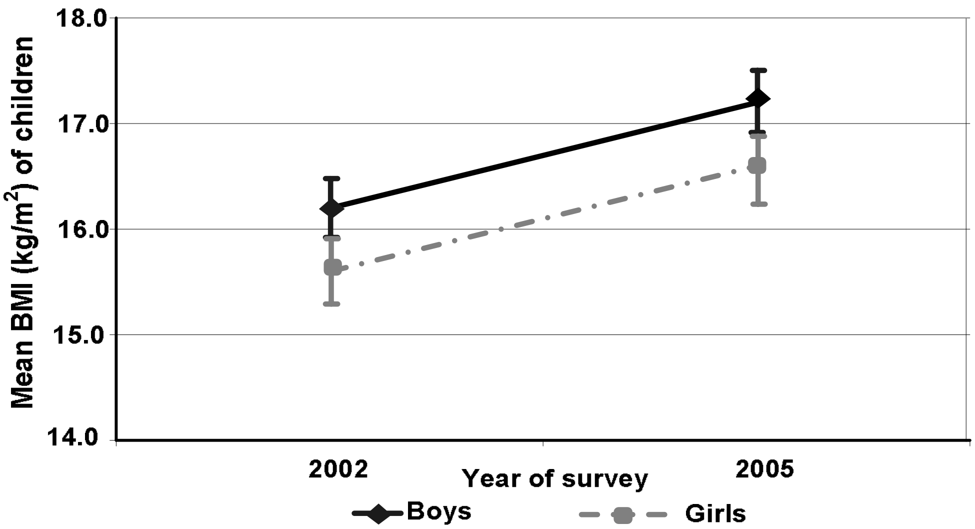


Figure 5-3 Trends in BMI for children aged 4 to 5 years from 2002 and 2005

Mean BMI and 95% confidence intervals for children in the 2002 and 2005 surveys

Table 5-3 presents the distribution of age, mean weight, height and BMI separately for boys and girls in the wealthy and less wealthy districts. The mean age of all children in the wealthy and less wealthy districts in the 2002 survey, was one to two months higher than for the corresponding groups in the 2005 survey ($p<0.05$). Overall, there was a greater increase in mean weight and BMI of children in less wealthy districts compared with wealthy districts from 2002 to 2005. Gender differences in the mean weight, height and BMI were observed in both wealthy and less wealthy settings in 2002 and 2005 ($p<0.05$).

Table 5-3 Characteristics of children by gender and districts in the 2002 and 2005 surveys

Means and 95% confidence interval of age, weight, height and BMI by gender and group of districts in the 2002 and 2005 surveys

Characteristics	Survey 2002 (n = 492)		Survey 2005 (n = 670)		p-value[1]
	Mean	95% CI	Mean	95% CI	
Wealthy districts (n = 330)	326		166		
Boys (n)	164		86		
Age (months)	58.2	56.6, 59.8	56.3	55.7, 57.0	0.0011
Weight (kg)	19.7	18.5, 20.9	20.4	19.6, 21.2	0.2191
Height (cm)	108.4	106.7, 110.0	108.2	107.2, 109.2	0.8299
BMI (kg/m²)	16.6	16.0, 17.3	17.3	16.8, 17.7	0.0458
Girls (n)	166		80		
Age (months)	57.7	56.8, 58.6	56.4	55.8, 57.0	0.021
Weight (kg)	18.5	17.4, 19.5	19.3	18.7, 19.9	0.0729
Height (cm)	106.8	105.5, 108.1	107.3	106.4, 108.3	0.4141
BMI (kg/m²)	16.1	15.4, 16.8	16.6	16.3, 17.0	0.054
Less wealthy districts	340		326		
Boys (n)	169		131		
Age (months)	57.1	56.0, 58.2	55.9	55.1, 56.7	0.0224
Weight (kg)	18.0	17.5, 18.6	19.9	18.9, 20.9	0.0000
Height (cm)	106.4	105.5, 107.4	107.2	106.3, 108.1	0.1452
BMI (kg/m²)	15.9	15.5, 16.2	17.2	16.7, 17.8	0.0000
Girls (n)	171		195		
Age (months)	57.6	56.6, 58.6	56.2	55.5, 56.8	0.0023
Weight (kg)	17.3	16.9, 17.8	18.7	17.8, 19.6	0.0000
Height (cm)	105.8	105.1, 106.6	106.2	105.2, 107.2	0.5393
BMI (kg/m²)	15.4	15.1, 15.7	16.5	16.0, 17.0	0.0000

[1] *p-value was calculated from Student's t-test*

Figure 5-4 reveals an increase in the mean weight for boys and girls from wealthy districts over the three years. However, the differences were not significant between the two time points (boys: p=0.2191; girl: p=0.0729)

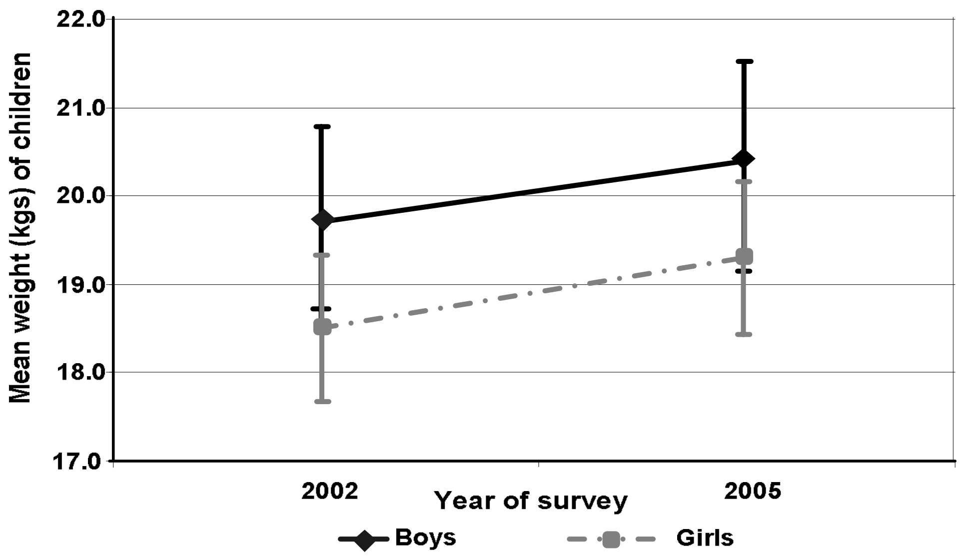


Figure 5-4 Trends in mean weight for children in wealthy districts from 2002 to 2005

Mean weight and 95% confidence intervals for children in the 2002 and 2005 surveys.

The mean weight for children from less wealthy districts has significantly increased over the three years for both genders (Figure 5-4). Specifically, the mean weight increased from 18.0 kg to 19.9 kg for boys (p<0.001) and from 17.3 kg to 18.7 kg for girls (p<0.001). There was no significant difference in mean weight between boys and girls in both years for children in less wealthy districts.

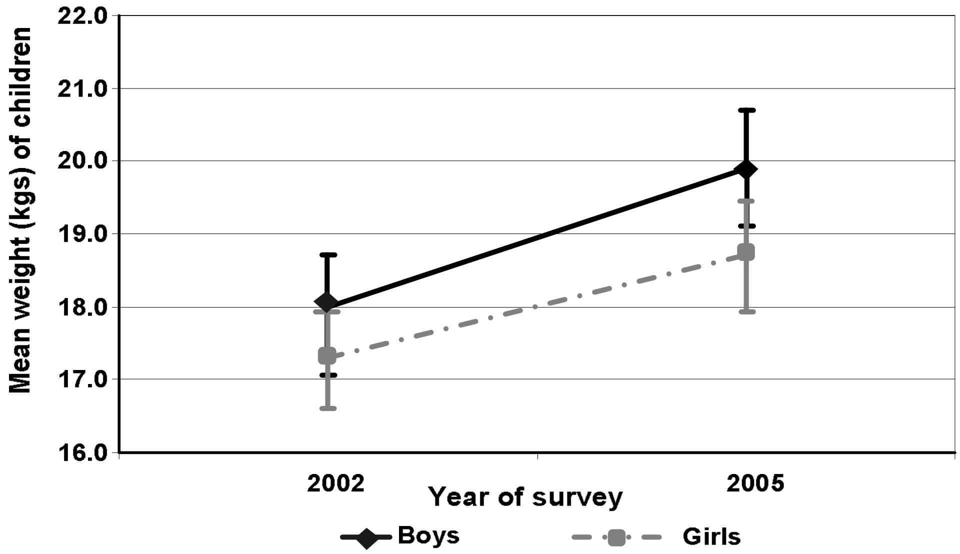


Figure 5-5 Trends in mean weight for children from less wealthy districts from 2002 to 2005

Mean and 95% confidence intervals of weight for children from less wealthy districts in the 2002 and 2005 surveys.

There was no statistically significant change in the mean height of children for both genders from wealthy districts over the three years (boys: p=0.8299; girls: p=0.41410) (Figure 5-6). There was also no statistically significant difference between boys and girls in both years.

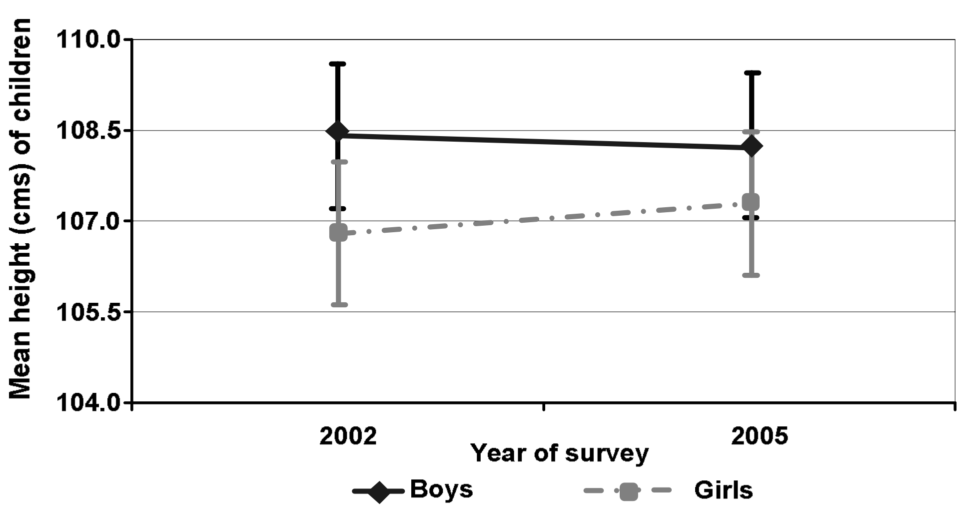


Figure 5-6 Trends in mean height for children from wealthy districts from 2002 to 2005

Mean and 95% confidence intervals for height of children from wealthy districts in surveys 2002 and 2005.

The mean height of children for both genders from less wealthy districts did not change significantly during the three year period (boys: p=0.1452; girls: p=0.5393) (Figure 5-7). There was no statistically significant difference between boys and girls in either year.

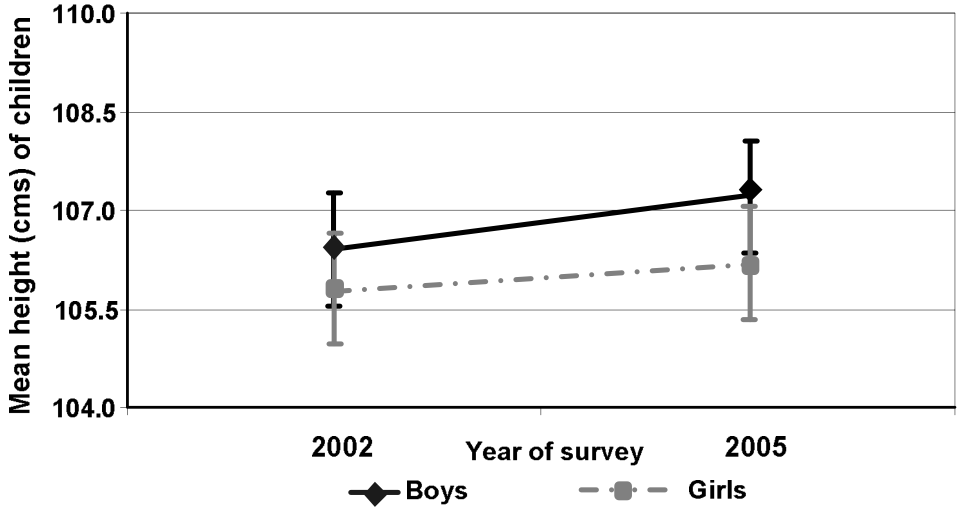


Figure 5-7 Trends in mean height for children from less wealthy districts from 2002 to 2005

Mean and 95% confidence intervals of mean height of children from less wealthy districts in the 2002 and 2005 surveys.

Figure 5-8 shows that mean BMI in boys and girls from wealthy areas increased over three years. However, these changes are not significantly different (boys: p=0.0558; girls: p=0.0540). Conversely, the mean BMI of children in both genders from less wealthy areas significantly increased over three years from 15.9 kg/m^2 to 17.2 kg/m^2 for boys (p=0.000) and from 15.4 kg/m^2 to 16.5 kg/m^2 for girls (p=0.000) (Figure 5-9).

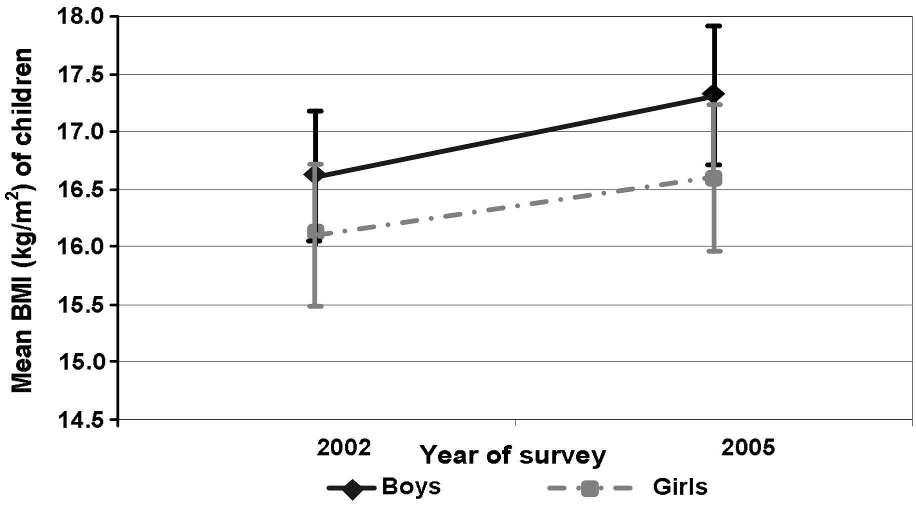


Figure 5-8 Trends in mean BMI for children from wealthy districts from 2002 to 2005

Mean and 95% confidence intervals of mean BMI for children from wealthy districts in the 2002 and 2005 surveys.

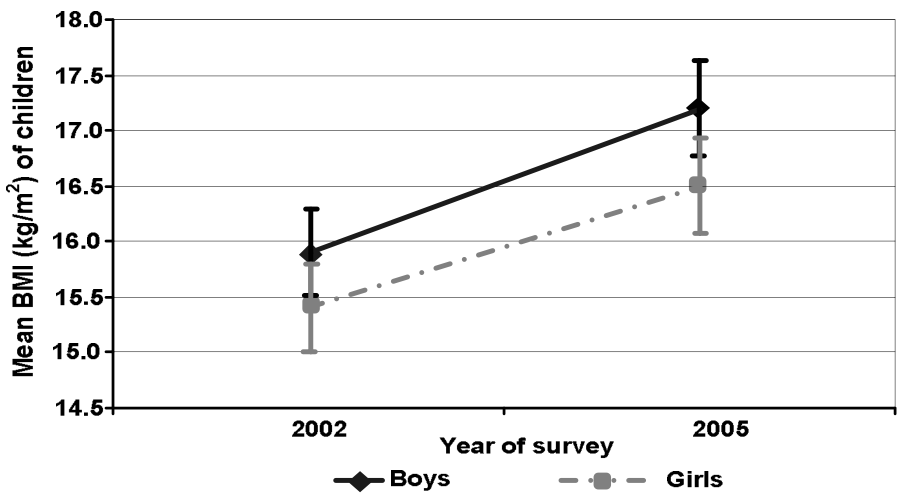


Figure 5-9 Trends in BMI for children from less wealthy districts from 2002 to 2005

Mean and 95% confidence intervals of BMI of children from less wealthy areas in the 2002 and 2005 surveys.

Figure 5-10 shows that the overall BMI Z-score distribution for children in 2005 has shifted further to the right than for children in 2002, and indicates that the BMI distribution for children in 2005 was higher than for children in 2002. In addition, the BMI Z-score distribution curve for children in the 2005 survey was above the CDC reference curve indicating a higher BMI in this child population in HCMC than for children in the reference population.

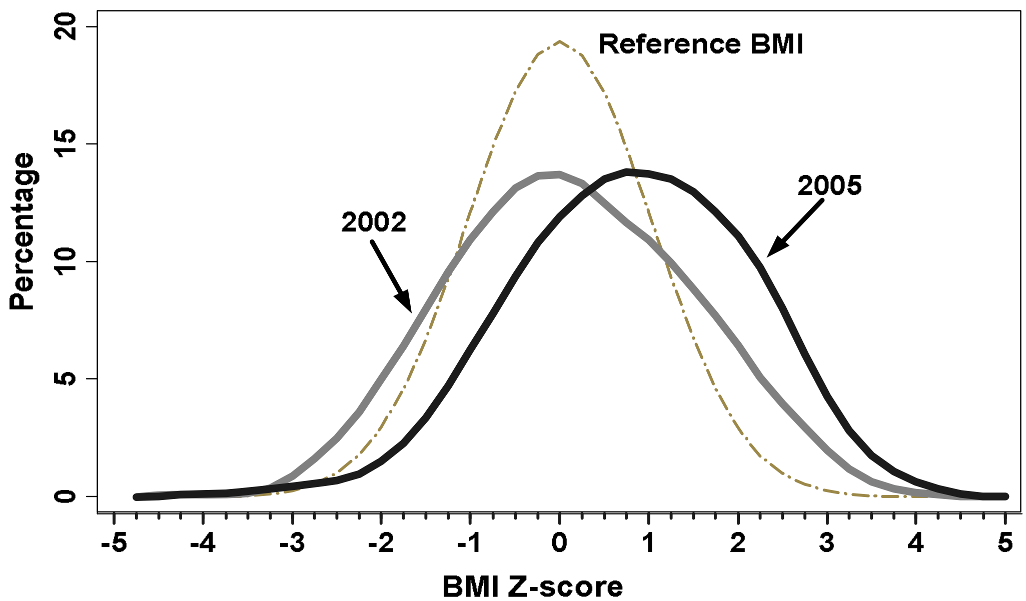


Figure 5-10 Plot of Lowes curves for the BMI-for-age Z-score distributions by year of survey.
Plot of Lowes curves for the BMI-for-age Z-score distributions for children aged 4 to 5 years in urban areas of HCMC by 2002 versus 2005 surveys.

Figure 5-11 shows the BMI Z-score distributions for boys in the 2002 survey versus the 2005 survey. The BMI Z-score curves for boys in the two surveys were skewed and shifted to the right compared with the CDC 2000 reference. However, the BMI Z-score distribution for boys in 2005 was further skewed to the right than for boys in 2002. This implies that the overweight status of boys in 2005 was more severe than in 2002. Similar trends in BMI Z-score distribution curves were found for girls in the 2002 versus 2005 surveys (Figure 5-11). The BMI Z-score distribution for girls in the 2005 survey was skewed to the right, compared with that for girls in 2002.

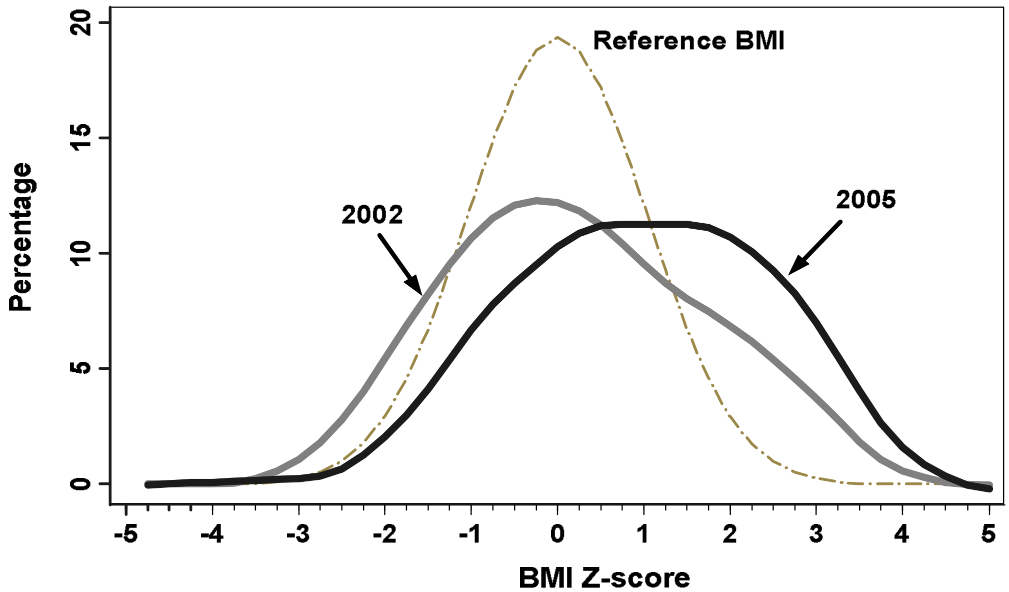


Figure 5-11 Plot of Lowes curves for the BMI-for-age Z-score distributions for boys by year of survey.

Plot of Lowes curves for the BMI-for-age Z-score distributions for boys aged 4 to 5 years by 2002 versus 2005 surveys

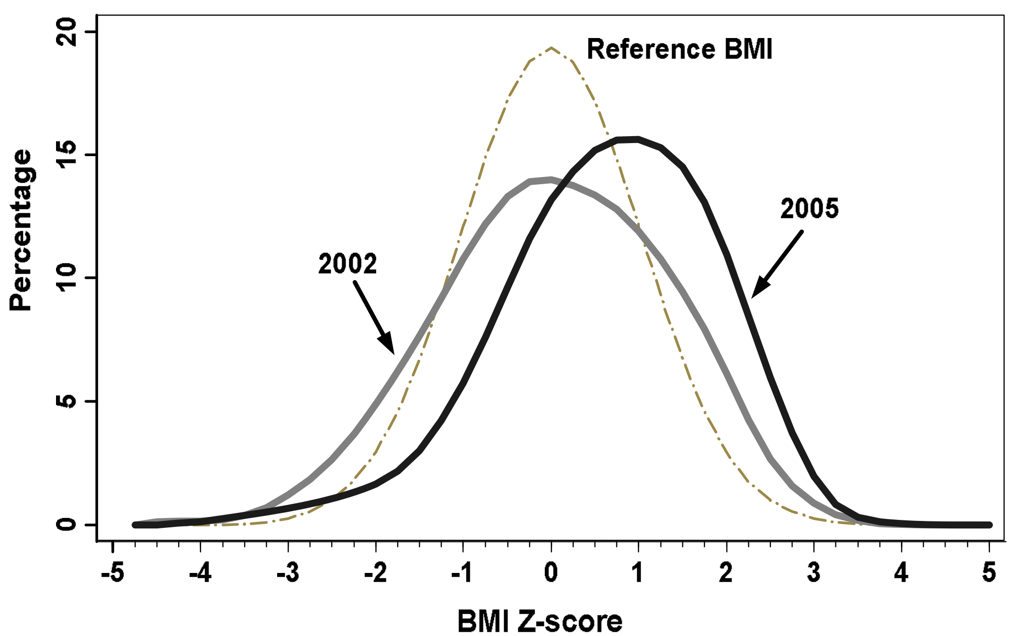


Figure 5-12 Plot of Lowes curves for the BMI-for-age Z-score distributions for girls by year of surveys.

Plot of Lowes curves for the BMI-for-age Z-score distributions for girls aged 4 to 5 years by 2002 versus 2005 surveys.

Figure 5-13 plots the BMI Z-score curves of children from wealthy districts in the 2002 versus the 2005 survey. There was not much difference in the distribution of BMI Z-score curves on the right hand side of the distribution between the two different points of time. However, an examination of the left hand side of the distribution indicates that the BMI Z-score curve for children in 2005 has shifted further to the right than for children in 2002. This implies that under-nutrition has decreased in 2005 compared to that in 2002.

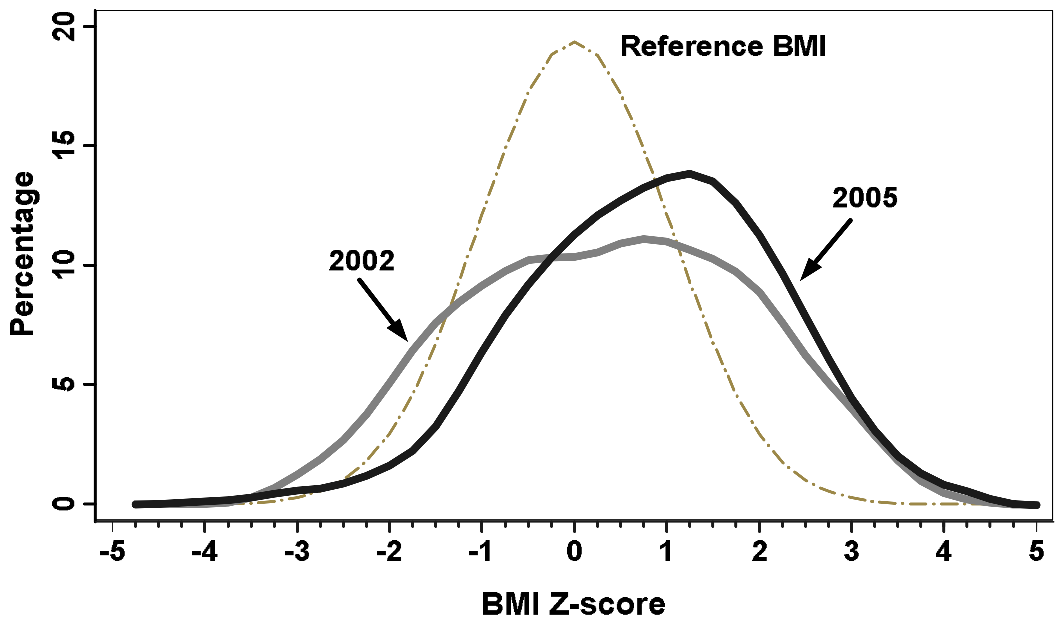


Figure 5-13 Plot of Lowes curves for the BMI-for-age Z-score distribution in wealthy districts by year of survey

Plot of Lowes curves for the BMI-for-age Z-score distribution for children aged 4 to 5 years in wealthy districts by 2002 versus 2005 surveys

The whole BMI Z-score curve distribution for children from less wealthy districts in 2005 has skewed to the right compared with children in 2002 (Figure 5-14). Thus, the BMI of children from less wealthy areas in 2005 was higher than that in 2002. Also the shift toward higher values (shifted to the right) in BMI Z-score distribution has taken place more strongly in children from less wealthy districts compared with children from wealthy areas.

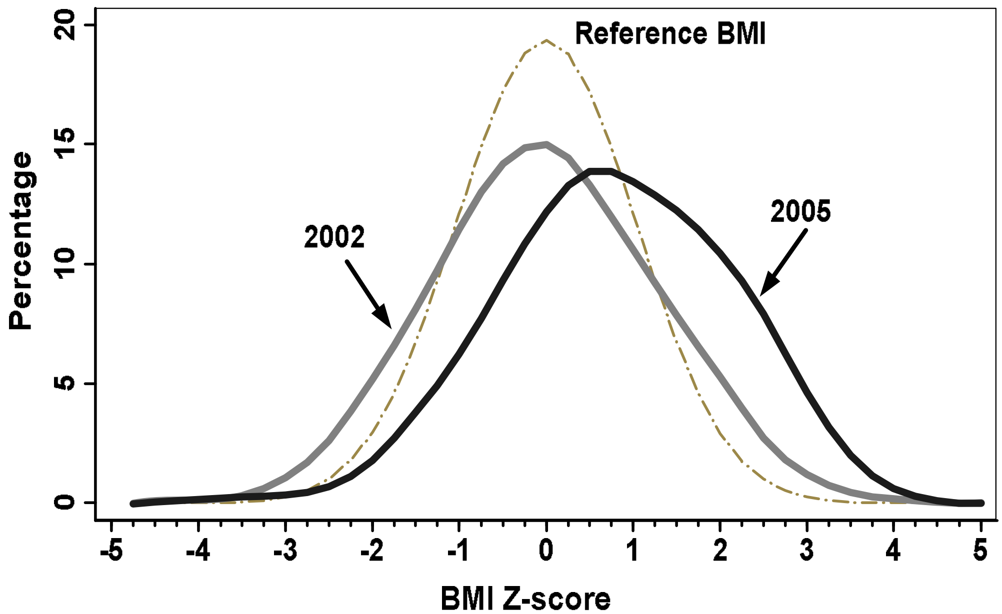


Figure 5-14 Plot of Lowes curves for the BMI-for-age Z score distributions in less wealthy districts by year of survey

Plot of Lowes curves for the BMI-for-age Z score distributions for children aged 4 to 5 years in less wealthy districts by 2002 versus 2005 surveys.

The changes in patterns of underweight, stunting and wasting of children by gender in the two surveys are shown in Table 5-4. In general, the prevalence of underweight and wasting in both genders has decreased with statistical significance over the three year period (underweight: p=0.000; wasting: p=0.000). There was a decrease in the prevalence estimate for stunting but this was not significant.

Table 5-4 Prevalence of underweight, stunting, wasting by gender in 2002 and 2005 surveys

Percentage and 95% confidence intervals of underweight, stunting and wasting amongst children in urban areas of HCMC in the 2002 and 2005 surveys. Underweight, stunting and wasting were defined as weight for agez-score, height for age z-score and BMI z-score <5th percentile based on CDC 2000 Growth Reference (Kuczmarkski et al., 2000)

Nutritional status	Survey 2002 (N = 492)		Survey 2005 (N = 670)		p-value[1]
	Percentage	95% CI	Percentage	95% CI	
Boys					
Underweight	10.1	6.4, 15.7	2.6	1.2, 5.2	0.000
Stunting	5.1	2.4, 10.3	2.4	1.3, 4.4	0.147
Wasting	7.8	5.0, 12.1	1.6	0.5, 4.8	0.000
Girls					
Underweight	10.2	7.0, 14.7	2.9	1.4, 5.7	0.001
Stunting	6.2	3.9, 9.7	2.2	0.9, 5.3	0.009
Wasting	9.1	6.2, 13.3	3.6	1.8, 7.1	0.007

[1] p-value was calculated from the Pearson chi-square test

Table 5-5 shows the changes in patterns of underweight, stunting and wasting from 2002 to 2005 by type of district. A statistically significant decrease in the prevalence of underweight (p=0.011) and wasting (p=0.004) over the three years occurred in the less wealthy districts, but not in the wealthy districts. In terms of stunting, there was no statistically significant change over the three years in both groups of districts.

Table 5-5 Prevalence of underweight, stunting and wasting by districts in the 2002 and 2005 surveys.

Percentage and 95% confidence intervals of underweight, stunting and wasting in children in wealthy and less wealthy districts of HCMC in the 2002 and 2005 surveys. Underweight, stunting and wasting was defined as weight for age z-score, height for age z-score and BMI z-score <5th percentile based on CDC 2000 Growth Reference

Nutritional status	Survey 2002 (N = 492)		Survey 2005 (N = 670)		p-value[1]
	Percentage	95% CI	Percentage	95% CI	
Wealthy districts					
Underweight	9.6	4.1, 20.8	3.9	1.8, 8.3	0.011
Stunting	5.4	1.7, 16.0	2.7	1.3, 5.5	0.130
Wasting	9.0	5.3, 15.0	3.1	1.1, 8.3	0.004
Less wealthy districts					
Underweight	10.4	7.2, 14.8	2.1	1.1, 3.9	0.016
Stunting	5.8	3.8, 8.8	2.1	0.9, 4.4	0.704
Wasting	8.3	5.7, 12.0	2.4	1.1, 4.9	0.002

[1] p-value was calculated from the Pearson chi-square test

Table 5-6 looks at the gender differences in the change in underweight, stunting and wasting prevalence from 2002 to 2005 in both groups of districts. Only girls in less wealthy districts demonstrated a statistically significant decrease in the prevalence of underweight during the three years (p=0.000). There was no clear gender difference in the changes in underweight prevalence for children in wealthy districts, or in the stunting or wasting prevalence for the whole urban area.

Table 5-6 Prevalence of underweight, wasting and stunting by gender and districts in urban areas of HCMC in 2002 and 2005 surveys

Percentage and 95% confidence interval of underweight, wasting and stunting in children by gender and districts in urban areas of HCMC in 2002 and 2005 surveys. Underweight, stunting and wasting were defined as weight for age z-score, height for age z-score and BMI z-score <5th percentile based on CDC 2000 Growth Reference

Nutritional status	Survey 2002 (N = 492)		Survey 2005 (N = 670)		p-value[1]
	Percentage	95% CI	Percentage	95% CI	
Wealthy districts					
Boys					
Underweight	8.1	3.0, 20.2	1.8	0.6, 5.3	0.016
Stunting	4.7	0.8, 22.8	3.7	2.0, 6.6	0.704
Wasting	9.3	4.3, 18.8	1.2	0.3, 4.9	0.002
Girls					
Underweight	10.2	7.0, 14.7	6.0	2.5, 13.7	0.150
Stunting	6.3	2.4, 15.1	1.8	0.4, 8.2	0.227
Wasting	8.8	3.6, 19.7	4.8	1.5, 14.4	0.066
Less wealthy districts					
Boys					
Underweight	11.5	6.7, 18.8	3.0	1.1, 7.6	0.003
Stunting	5.3	2.7, 10.4	1.8	0.6, 5.5	0.088
Wasting	6.9	3.9, 11.8	1.8	0.4, 8.0	0.026
Girls					
Underweight	9.7	6.7, 14.1	1.1	0.3, 5.1	0.000
Stunting	6.2	3.5, 10.6	2.3	0.7, 7.7	0.075
Wasting	9.3	5.9, 14.2	2.9	1.1, 7.7	0.013

[1] p-value was calculated from the Pearson chi-square test

Table 5-7 shows the prevalence of overweight and obesity by gender in the 2002 and 2005 surveys. Overall, the combined prevalence of overweight and obesity for both genders in 2005 was nearly double that of 2002 (36.8% and 21.4% respectively) and this difference was statistically significant (p=0.000). The increase in the prevalence of overweight and obesity over time has been greater for boys than for girls; especially, the prevalence of obesity alone for boys, which by 2005 had doubled compared with 2002 (21.7% and 11.6% respectively). This difference was also statistically significant (p=0.003).

Table 5-7 Prevalence of overweight and obesity by gender in urban areas of HCMC in 2002 and 2005 surveys.

Percentage and 95% confidence interval of overweight and obesity in children from urban areas of HCMC in 2002 and 2005 surveys. Overweight and obesity are defined according to IOTF definition.

Nutritional status	Survey 2002 (N = 492)		Survey 2005 (N = 670)	
	Percentage	95% CI	Percentage	95% CI
All	21.4	17.5, 25.8	36.8	32.0, 41.8
Boys (combined)	22.6	17.2, 29.1	40.8	34.2, 47.8
Overweight	11.1	6.9, 17.3	19.1	15.7, 23.1
Obesity	11.6	8.0, 16.5	21.7	16.8, 27.5
Girls (combined)	20.4	15.6, 26.2	32.8	25.8, 40.8
Overweight	15.7	11.7, 20.7	21.8	17.3, 27.1
Obesity	4.7	2.8, 8.0	11.1	6.4, 18.3

Figure 5-15 illustrates the changes in combined prevalence of overweight and obesity in children aged four to five years by gender over time. There was a significant increase in the combined prevalence of overweight and obesity in boys from 22.6% in 2002 to 40.8% in 2005 (p=0.000). There was also an increase in the prevalence of overweight and obesity in girls which neared statistical significance (p=0.067).

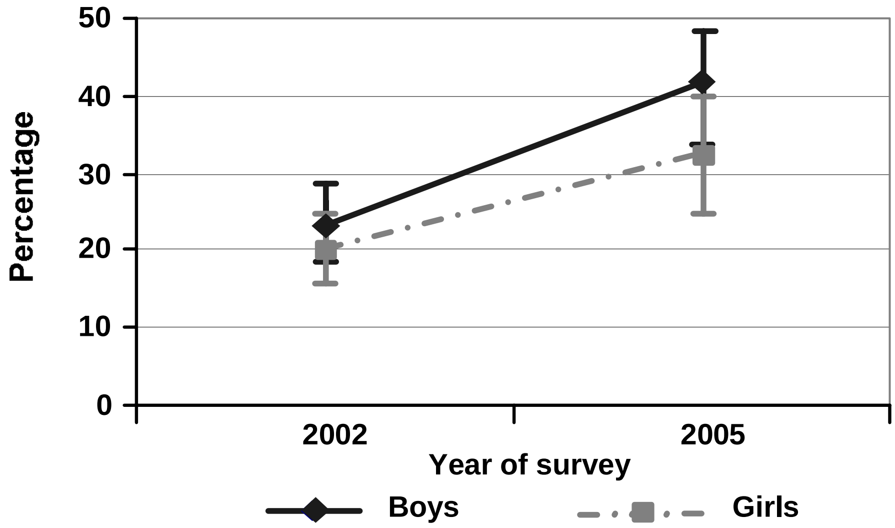


Figure 5-15 Trends in combined prevalence of overweight and obesity in children by gender from 2002 to 2005

Percentage and 95% confidence intervals of combined overweight and obesity in children in the 2002 and 2005 surveys

The prevalence of overweight in both genders increased but was not significant over the period of 2002 to 2005 (Figure 5-16). However, there was a marked increase in the prevalence of obesity for boys over the same period, as seen in Figure 5-17, from 11.6% in 2002 to 21.7% in 2005 (p=0.003).

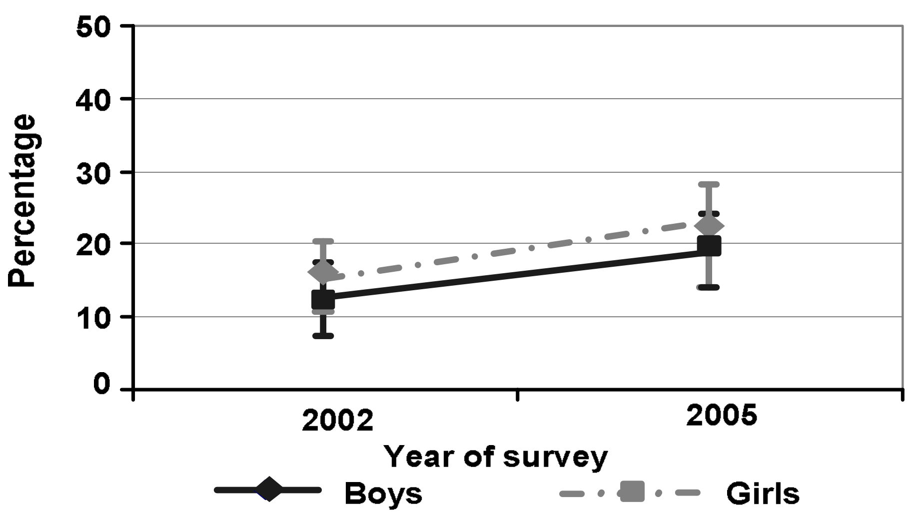


Figure 5-16 Trends in prevalence of overweight in children from 2002 to 2005

Percentage and 95% confidence intervals of overweight in children in the 2002 and 2005 surveys

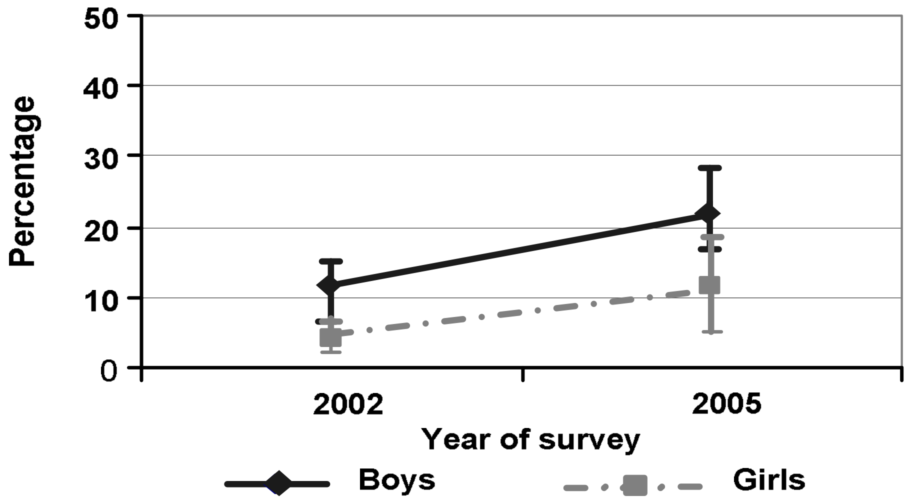


Figure 5-17 Trends in prevalence of obesity in children aged 4 to 5 years from 2002 to 2005
Percentage and 95% confidence intervals of obesity in children in the 2002 and 2005 surveys

Table 5-8 shows the time trend in the prevalence of overweight and obesity for both genders by districts from 2002 to 2005. The combined prevalence of overweight or obesity slightly increased in wealthy districts (30.1% versus 38.5%; p=0.067) but a statistically significant increase in this prevalence estimate occurred for children from less wealthy districts (16.9% versus 35.9%; p=0.000). There was a gender difference in the change in the prevalence of obesity in children from less wealthy districts. The prevalence of obesity in boys in 2005 was three times that observed in 2002 (22.5% versus 6.9%) and this difference was statistically significant (p=0.000).

Table 5-8 Prevalence of overweight and obesity by districts and gender in 2002 and 2005 surveys.

Percentage and 95% confidence interval of overweight and obesity in children by districts and gender from urban areas of HCMC in 2002 and 2005 surveys. Overweight and obesity are defined according to IOTF definition.

Nutritional status	Survey 2002 (N = 492)		Survey 2005 (N = 670)	
	Percentage	95% CI	Percentage	95% CI
Total overweight/obesity	21.4	17.5, 25.8	36.8	32.0, 41.8
Wealthy districts	30.1	21.9, 39.9	38.5	32.3, 45.0
Boys (combined)	31.4	20.9, 44.2	39.6	30.0, 50.1
Overweight	12.8	5.9, 25.4	19.5	13.8, 26.8
Obesity	18.6	11.8, 28.2	20.1	14.3, 27.5
Girls (combined)	28.8	17.6, 43.2	37.4	28.8, 46.7
Overweight	20.0	10.9, 33.8	25.3	17.2, 35.6
Obesity	8.8	3.9, 18.4	12.1	6.2, 22.3
Less wealthy districts	16.9	13.3, 21.2	35.9	29.4, 42.9
Boys (combined)	16.8	11.4, 24.1	41.4	32.1, 51.5
Overweight	9.9	5.2, 18.1	18.9	14.4, 24.5
Obesity	6.9	3.5, 13.2	22.5	15.5, 31.5
Girls (combined)	16.9	12.0, 23.4	30.4	20.3, 42.8
Overweight	13.9	9.8, 19.2	19.9	14.2, 27.1
Obesity	3.1	1.4, 6.7	10.5	4.5, 22.7

Figure 5-18 shows the time trend in the combined prevalence of overweight and obesity by districts and reveals a more rapid increase in overweight and obesity in children from less wealthy districts compared with children from wealthy districts. This resulted in a similar prevalence of overweight and obesity between the two urban areas by 2005 (Figure 5-18)

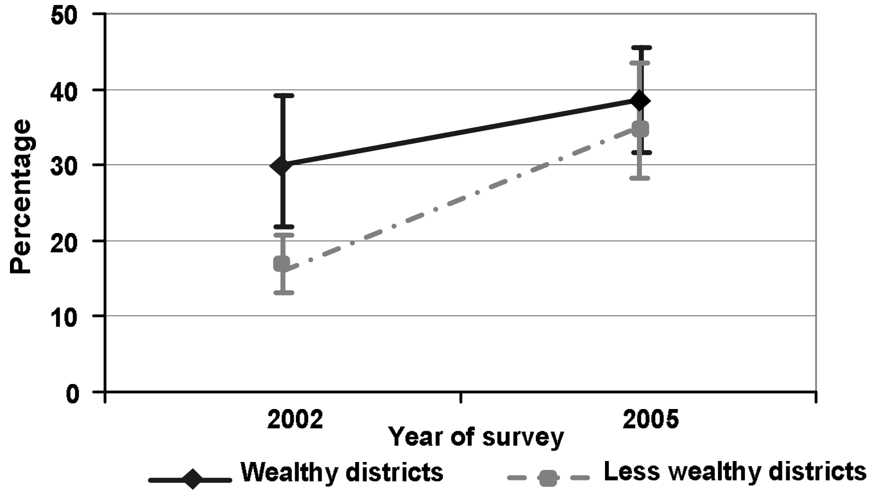


Figure 5-18 Trend in prevalence of overweight/obesity in children by districts from 2002 to 2005.

Percentage and 95% confidence intervals of overweight/obesity in children in the 2002 and 2005 surveys

Figures 5-19 indicates that the rapid changes in the prevalence of overweight and obesity in children from less wealthy urban districts was primarily from changes in the prevalence of obesity alone in boys rather than changes in girls.

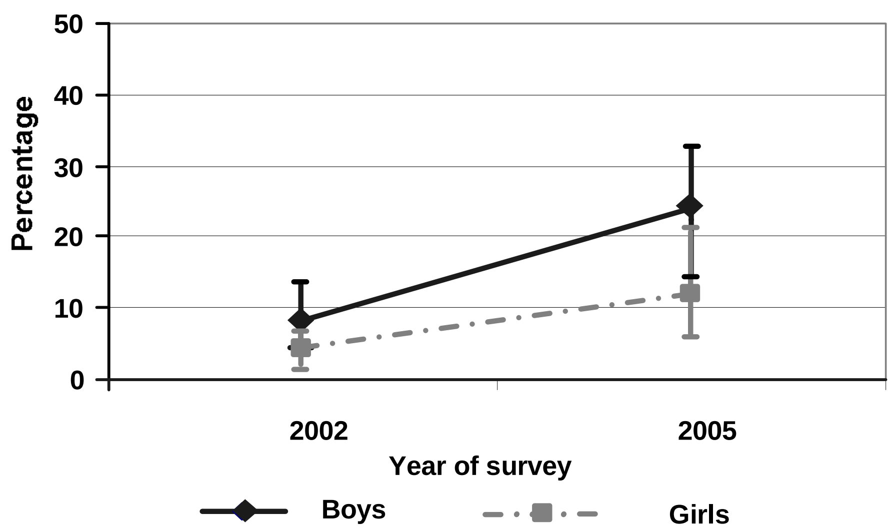


Figure 5-19 Trends in prevalence of obesity in children from less wealthy districts from 2002 to 2005

Percentage and 95% confidence intervals of overweight/obesity among children in the 2002 and 2005 surveys

Time trends in the prevalence of overweight and/or obesity by gender, age groups, parental overweight and education levels are presented in Table 5-9. The combined prevalence of overweight and obesity in boys increased significantly over time across age groups ($p<0.01$), except for the 60 to 65 month age group. Similar trends in the increase of the combined prevalence of overweight and obesity over the three year period were found for girls but were not significantly different.

There were few changes in the prevalence of overweight and/or obesity in relation to the overweight status of parents over time. In both surveys, the highest prevalence of overweight and obesity was found in children where both parents were overweight compared with children whose parents were of normal weight or who had one overweight parent. The highest education level of parents was associated with the highest combined prevalence of overweight and obesity but was not related to the change in the prevalence of overweight and obesity in children from both genders.

Table 5-9 Prevalence of overweight and/or obesity by age, parental overweight and parental education levels in urban areas of HCMC in the 2002 and 2005 surveys

Percentage and 95% confidence intervals for overweight and/or obesity in children aged 4 to 5 years by gender, age group, parental overweight, parental education level in urban areas of HCMC in the 2002 and 2005 surveys

Characteristics	Survey 2002						Survey 2005					
	Overweight		Obese		Combined		Overweight		Obese		Combined	
	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI
Age groups (months)												
48-53	7.8	3.5, 16.6	7.8	3.5, 16.7	15.6[1]	9.7, 24.2	16.3	10.3, 25.0	17.8	11.7, 26.2	34.1[1]	25.0, 44.7
54-59	9.9	3.5, 24.8	12.7	6.8, 22.5	22.6[1]	13.7, 35.0	19.1	13.6, 26.2	25.1	18.0, 33.9	44.3[1]	36.1, 52.8
60-65	14.7	8.6, 23.9	13.5	7.5, 23.1	28.2	19.3, 39.0	24.6	14.1, 39.5	21.6	12.7, 34.2	46.2	30.3, 62.9
Parental overweight[3]												
No parents overweight	8.8	4.3, 17.2	6.9	3.6, 12.9	15.7[2]	10.4, 23.1	19.8	15.4, 25.2	18.8	11.5, 29.0	38.6[2]	28.5, 49.8
Either parents overweight	12.8	6.2, 24.4	17.1	10.5, 26.5	29.9	20.4, 41.5	15.0	8.2, 25.6	26.0	18.4, 35.2	40.9	29.5, 53.3
Both parents overweight	16.7	5.5, 40.9	11.1	2.5, 37.7	27.8[1]	12.0, 52.0	30.8	14.4, 53.9	35.5	20.3, 54.4	66.3[1]	49.4, 79.9
Parental education level												
Primary school	0	_	11.8	3.0, 36.6	11.8	3.0, 36.6	24.4	11.1, 45.7	12.2	1.4, 57.4	36.7	10.3, 74.6
Secondary school	7.6	2.5, 20.5	1.9	0.3, 11.9	9.5[2]	3.3, 24.3	19.8	11.9, 31.0	13.5	8.2, 21.4	33.2[2]	24.7, 43.0
High school	9.8	4.8, 18.7	16.4	11.0, 23.6	26.1	18.4, 35.6	19.5	14.0, 26.4	22.3	15.8, 30.7	41.8	33.3, 50.8
University	20.0	9.2, 38.1	12.8	6.9, 22.5	32.8	21.3, 46.9	17.7	13.3, 23.2	29.6	19.9, 41.6	47.3	36.8, 58.1

[1] *$p<0.01$*
[2] *$p<0.001$*
[3] *Overweight in parents defined as BMI ≥ 23 (Corazon et al., 2004)*

Table 5-9 Prevalence of overweight and/or obesity by age, parental overweight and parental education levels in urban areas of HCMC in the 2002 and 2005 surveys (cont)

Percentage and 95% confidence intervals for overweight and/or obesity in children aged 4 to 5 years by gender, age group, parental overweight, parental education level in urban areas of HCMC in the 2002 and 2005 surveys

Characteristics	Survey 2002						Survey 2005					
	Overweight		Obese		Combined		Overweight		Obese		Combined	
	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI	Percentage	95% CI
Age groups (months)												
48-53	12.0	5.9, 23.0	2.7	0.7, 10.4	14.7	7.5, 26.8	22.7	15.2, 32.4	7.3	4.0, 12.9	29.9	21.0, 40.7
54-59	17.5	11.0, 26.7	6.2	2.9, 12.7	23.7	16.0, 33.6	21.4	15.7, 28.4	10.6	5.4, 19.7	32.0	23.5, 41.9
60-65	16.5	10.7, 24.6	4.9	1.9, 11.7	21.4	14.8, 29.9	21.2	10.9, 37.1	18.1	8.2, 35.6	39.3	24.3, 56.7
Parental overweight[3]												
No parents overweight	10.6	5.9, 18.2	2.1	0.7, 6.4	12.7	7.4, 21.0	20.9	14.5, 28.9	5.0	2.6, 9.3	25.8	18.6, 34.7
Either parents overweight	20.2	12.9, 30.2	7.4	3.8, 13.8	27.6	19.1, 38.1	21.8	15.5, 29.8	14.3	7.0, 26.8	36.1	26.4, 47.1
Both parents overweight	28.6	12.3, 53.4	9.5	2.3, 32.1	38.1	17.7, 63.8	33.0	14.7, 58.4	29.2	16.8, 45.7	62.2	44.6, 77.1
Parental education level												
Primary school	8.4	2.1, 28.2	0	_	8.4	2.1, 28.2	9.7	2.2, 34.2	13.7	6.1, 28.0	23.4	11.3, 42.2
Secondary school	5.7	2.1, 14.6	0	_	5.7	2.1, 14.6	12.2	6.9, 20.4	10.6	3.4, 28.6	22.8	11.8, 39.5
High school	15.7	9.3, 25.2	6.9	3.3, 13.9	22.6	14.2, 33.9	22.2	14.6, 32.3	10.8	5.2, 21.1	33.1	23.1, 44.8
University	32.8	22.8, 44.7	9.8	4.4, 20.6	42.7	31.7, 54.4	31.1	23.5, 39.9	11.6	6.7, 19.2	42.7	32.5, 53.5

[1] $p<0.01$
[2] $p<0.001$
[3] Overweight in parents defined as BMI ≥ 23 (Corazon et al., 2004)

Logistic regression was used to assess the trends in the prevalence of overweight and/or obesity from 2002 to 2005 in boys and girls separately and adjusted for gender, age, school location, parental overweight and parental education levels. These models showed significant increases in the prevalence of combined overweight and obesity and with obesity alone from 2002 to 2005 in both genders (Table 1-10). The odds of becoming overweight and obese or obese over time, were similar for both genders with the odds of being overweight/obese and obese for boys of 2.61 (95% CI: 1.73, 3.96) and 2.45 (95% CI: 1.22, 4.92) respectively, and for girls of 1.80 (95% CI: 1.19, 2.70) and 2.45 (95% CI: 1.22, 4.92) respectively.

Table 5-10 Multiple logistic regression of overweight and/ or obesity in children over time

Odds ratios and 95% confidence intervals for prevalence of overweight and/or obesity over time adjusted for, age, districts, and parental overweight and education levels

Characteristics	Overweight/Obesity[1]				Obesity[1]			
	OR[2] (95% CI)				OR[2] (95% CI)			
	Boys		Girls		Boys		Girls	
Age in months	1.03	1.0, 1.06	1.02	0.98, 1.07	1.03	0.97, 1.09	1.05	0.97, 1.14
Year of survey								
2002	1.00		1.00		1.00		1.00	
2005	2.61	1.73, 3.96	1.80	1.19, 2.70	2.42	1.43, 4.09	2.45	1.22, 4.92
Districts								
Wealthy	1.00						1.00	
Less wealthy	0.97	0.66, 1.42	0.76	0.51, 1.13	1.01	0.63, 1.62	0.77	0.41, 1.42
Parental overweight								
No parent overweight	1.00		1.00		1.00		1.00	
One parent overweight	1.49	0.99, 2.24	1.83	1.21, 2.77	2.01	1.21, 3.33	2.91	1.39, 6.10
Both parents overweight	2.59	1.37, 4.89	4.33	2.31, 8.09	2.49	1.20, 5.20	5.72	2.35, 13.95
Parental education level								
Primary school	1.00		1.00		1.00		1.00	
Secondary school	1.19	0.40, 3.53	0.74	0.27, 2.07	0.64	0.16, 2.54	0.77	0.15, 4.05
High school	2.09	0.73, 5.97	1.82	0.70, 4.72	1.69	0.47, 6.08	1.35	0.29, 6.29
University	2.76	0.95, 8.05	3.06	1.16, 8.06	2.15	0.58, 7.90	1.43	0.30, 6.85

[1] Overweight and obesity according to IOTF definitions (Cole et al., 2000)
[2] Odd ratios and 95% Cis were calculated from logistic regression
[3] Overweight in parents defined as BMI ≥ 23 (Corazon et al., 2004)

5.4 Discussion

The findings provide evidence of accelerated trends in the prevalence of overweight and/or obesity, along with a substantial decrease in the prevalence of underweight in children aged four to five years from 2002 to 2005 in urban areas of HCMC. Overall, there was significant increase in prevalence of overweight and obesity, as well as in mean weight and BMI rather than height in this child population over the three year period. However, the rate of these changes was greater in children from less wealthy districts than for children from wealthy districts. Thus, the importance of overweight and obesity in preschool aged children in urban areas of HCMC is characterised not only at its magnitude (Chapter 4) but also by the rapidly upward trend in prevalence over the three year period from 2002 to 2005.

Similar trends have been observed in the prevalence of overweight and obesity in young child populations in other developing countries during the past decade. Data from the China Health and Nutritional Survey collected from 1989 to 1997 has shown a dramatic increase in the prevalence of overweight and obesity among children aged 2 to 6 years in the urban areas. This study, using the IOTF classification for overweight and obesity, reported the prevalence of overweight increased from 14.6% to 28.6%, and that the prevalence of obesity increased from 1.5% to 12.6% over the period of study (Luo and Hu, 2002). In Brazil, time trends from 1975 to 1996 in the prevalence of stunting, wasting and overweight in children 1 to 4 years, has revealed a strong continuous decrease in the prevalence of stunting and wasting, and a doubling in the prevalence of overweight (defined as weight-for-height index >+2 SD based on 1978 WHO reference population) among preschool children from higher income groups over the period of survey (3.3% to

6.9% respectively) (Monteiro et al., 2002). In a report of trends in overweight and obesity in children in Latin American countries, a similar phenomena was documented among children in grade 1 in Chile, with the prevalence of overweight (weight-for-height index >+2 SD based on 1978 WHO reference population) increasing 2.9 times for boys and 2.2 times for girls over the 13 years from 1987 to 2000 (Abala et al., 2002). Compared with other studies reporting trends in overweight and obesity in urban preschool children, it appears that the 57% increase per year in the prevalence of overweight and obesity in preschool children in HCMC was greater than that reported in China (27%) (Luo and Hu, 2002), Brazil (17%) (Monteiro et al., 2002) and Chile (12%) (Abala et al., 2002).

In the present study, increases in overweight and obesity were greater for boys than for girls, especially the prevalence of obesity in boys which nearly doubled over the three-year period (Table 5-7). More rapid increases in weight compared with height were observed in boys than in girls, leading to the gender differences observed in BMI over time. These findings are similar to those reported for adolescents from urban areas of HCMC from 2002 to 2004 where the prevalence of overweight and obesity in boys increased by 113% and only 39% in girls (Hong, 2005).

In contrast, several publications on the prevalence and trends in overweight and obesity among preschool children in developed countries have shown an opposite trend by gender with greater increases in overweight and obesity reported for girls than for boys (Michael et al., 2001, Cynthia et al., 2002, Stamatakis et al., 2005). These gender differences between Vietnam and Western countries can be explained by Vietnamese culture where boys are preferred over girls and often receive more of the family's resources. However, the role of male gender preference needs further examination in future studies of overweight and obesity in preschool children in Vietnam.

In this study, it was not possible to examine the association between socio-economic status with time trends in overweight and obesity in children from these two surveys since information on household wealth was not measured in the 2002 survey. Family socio-economic status has been found to be strongly associated with changes in the prevalence of overweight and obesity in children in both industrialized and developing countries but with an impact in different directions. In a study on the trends in overweight and obesity among adolescents in urban areas of HCMC from 2002 to 2004, the prevalence of overweight/obesity increased 1.7 times in the wealthiest one third of households while it increased only 1.3 times in the poorest one third of the households (Hong, 2005).

In contrast, a report on trends in overweight and obesity from 1974 to 2003 among children aged 5 to 10 years in England, noted more marked increases in overweight and obesity in children from families of lower socio-economic status (Stamatakis et al., 2005). Although the economic status of the participant households was not measured for this study, the wealth status of the district in which the school was located was classified. The greatest changes in BMI status and prevalence of overweight and obesity was observed in less wealthy districts, making the greatest contribution to the overall changes in BMI status, and the prevalence of overweight and obesity in children from HCMC over the three-year period. The high prevalence of overweight and obesity in the young child population in wealthy districts has been shown in the 2002 and the 2005 data, however, there is no preceding data available to indicate when this epidemic began. Although the prevalence in overweight and obesity in preschool children from less wealthy urban districts commenced from a lower level of that observed in wealthy urban districts, the greater rate of increase has resulted in a similar prevalence by 2005 to that of children from the wealthy urban areas. This implies that there have been substantial changes in the environment and lifestyle of families from less wealthy urban areas in recent years and that the socioeconomic differences between these groups of urban districts are narrowing. It is therefore necessary to understand what alterations in the environment lead to changes in dietary and physical activity behaviour in urban populations. Also, data are needed to assess and monitor the shift over time, in the diet and physical activity of preschool children.

Over the same period, this study has found a substantial decline in underweight and wasting in this population. There was a more marked improvement in the prevalence of underweight and wasting in less wealthy compared with wealthy urban areas. Thus, underweight and wasting, a major health problem in preschool children in HCMC in the 1980s, appears to be under control but is being replaced with an epidemic of overweight and obesity. This phenomena has also been reported in countries that are considered to be experiencing the final stage of a "nutrition transition" (Monteiro et al., 2002, Kain et al., 2005). However, the "nutrition transition" in urban HCMC appears to have been much faster than observed in other countries.

One limitation of this study is the use of different methodologies and sampling methods in the two surveys. The 2002 survey (Hung et al., 2003) was originally designed to measure the magnitude of overweight and obesity in children aged from 1 to 6 years in kindergartens in the whole of HCMC using a self administered questionnaire where parents were asked to measure socio-demographic factors. Some information collected in the 2005 survey was not collected in the 2002 survey. As a result, household socio-economic status, which is considered an important factor related to changes in overweight and obesity over time could not been examined in this study.

In addition, data on diet, physical activity patterns and the environment were not available in the 2002 survey (Hung et al., 2003). For these reasons, the factors associated with the time trends in overweight and obesity among this young child population could not be fully evaluated, in particular, the sharp upward trend in prevalence of overweight and obesity in less wealthy areas over the three year period.

Finally, the generalization of the findings in this study should be limited to children enrolled in kindergarten since it is estimated that approximately twenty percent of children in this age do not attend kindergarten in urban HCMC.

This study has found large increases in the prevalence of overweight and obesity as well as weight and BMI in children aged four to five years in urban areas of Ho Chi Minh City over a three year period. The urban areas of HCMC are now facing an increasing prevalence of overweight and obesity in both preschool children and adolescents. Since overweight and obesity in adolescents may be well established by the pre-adolescent period (Wardle et al., 2006), in the near future, the number of overweight adolescents may increase in HCMC if no effort is made to prevent obesity at an early age. In terms of the impact on short-term and long-term health consequences, as well as health economic costs, it is time for action to control and reverse the rapid upward trend in overweight and obesity in young children in HCMC and in other urban areas of Vietnam.

Chapter 6 Validation of the physical activity questionnaire

6.1 Introduction

The importance of physical activity for child health has been demonstrated in many studies reported in the literature. Different levels of intensity of activity are associated with health outcomes including childhood obesity and risks of obesity-related morbidity (Sothern et al., 1999, Steinbeck, 2001, Must and Tybor, 2005). In addition to the health benefits of increasing regular physical activity, reducing sedentary behaviour has been proposed as an effective strategy for the prevention of childhood obesity (Epstein et al., 2000, Reilly et al., 2002). Information on physical activity and sedentary behaviour, therefore, is essential in examining the role of physical activity and inactivity on health outcomes. Identifying current levels of activity enables the development of a strategy to promote physical activity in the future (Sirard and Pate, 2001).

Assessment of physical activity in children is challenging, particularly in young children (Welk et al., 2000). Because of biological and physiological characteristics, physical activity behaviour in children is characterised by intermittent and transitory activity which is different from older children and adults. In addition, the less developed cognitive skill and behaviour in young children prevent employing a number of physical activity assessment methods such as self-report (Welk et al., 2000).

Approaches used to measure physical activity in children vary in accuracy and include direct observation, doubly-labelled water, indirect calorimetry, heart rate monitoring, pedometer and accelerometer use and self- and proxy report. Although objective methods provide more precise assessments of physical activity in children, they require special equipment and are complicated to use with a large number of children (Sallis and Saelens, 2000). For this reason, efforts have been made to develop more feasible and valid methods to assess physical activity.

Despite a number of limitations, proxy-report is considered to be one of the most viable assessment techniques available for evaluating physical activity in young children at a population level. However it requires the development of a reliable and valid instrument for a given study population (Sirard and Pate, 2001). There are still few valid proxy-report instruments available for measurement of physical activity in young children (Sirard and Pate, 2001). Recently, an expert panel reviewing the knowledge of existing methods for assessing physical activity in children suggested that further research assessing validity and feasibility of proxy reports should be a priority (Janet et al., 2001).

Research findings in developed countries have indicated a declining trend in physical activity coupled with a secular increase in sedentary behaviour such as TV viewing and computer use in youth over the past decades (Peter and Chris, 2004, Nelson et al., 2006). There have been few studies examining the level of physical activity and sedentary behaviour in child populations in developing countries, including Vietnam. The lack of such data in the developing world in part may be due to a lack of valid and feasible instruments for use in assessing physical activity in children in population based studies.

The purpose of this chapter is to validate the proxy-report questionnaires used by parents and teachers to measure physical activity in terms of the level of intensity of physical activity and the extent of sedentary behaviour in children aged four to five years in urban Ho Chi Minh City (HCMC) Vietnam. This proxy questionnaire was used to assess physical activity for all children in the one year cohort study with the aim of examining the influence of physical activity, coupled with other potential risk factors, on the changes in adiposity and obesity development in the four to five year old population in urban HCMC.

6.2 Methodology

The survey methods used in this study are described in detailed in Chapter 3.

6.2.1 Data analysis

Questionnaires

The data from the teachers' and parents' forms were used to calculate an average time spent in sedentary behaviour and vigorous activity, as presented in detail in Chapter 3. In short, the questionnaires took into account the time spent in physical activities in both school and home settings on weekdays and weekends. The amount of time the child engaged in sedentary behaviour and vigorous activity on a typical weekday was summed from data given by the teacher and parents, except for the time for TV viewing since this activity only occurred in the home setting. The amount of time the child spent in each type of physical activity per day was calculated using data for that type of physical activity on a typical weekday, combined with appropriately weighted data for that type of physical activity on a typical day during weekends as reported by parents. The "weight" adjusted the physical activity for the different number of reporting days for weekdays (5) and for weekend days (2). The weighted physical activity time was calculated as follows:

Average amount of time for sedentary or vigorous activity per day = reported time spent for sedentary or vigorous activity per weekday (hours) * 5/7 + reported time spent for sedentary or vigorous activity per weekend day * 2/7

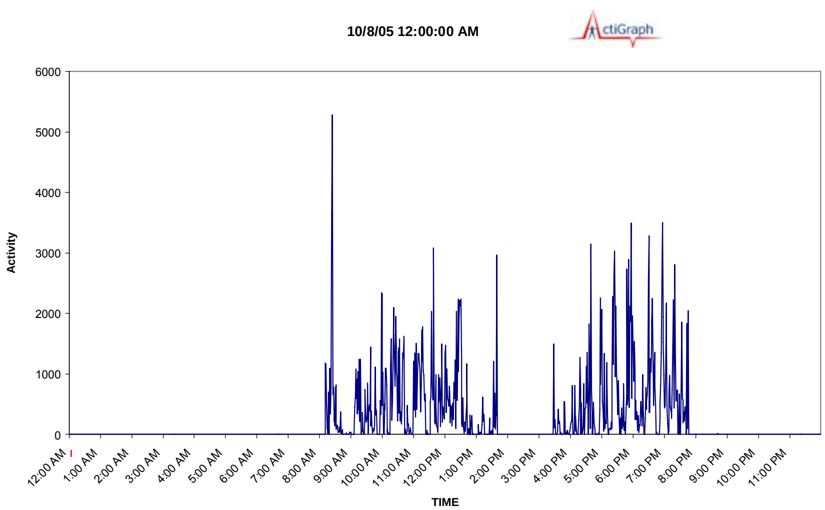
Thus, data from both questionnaires provided information on the duration (in minutes) the child engaged in the following types of physical activity per day:

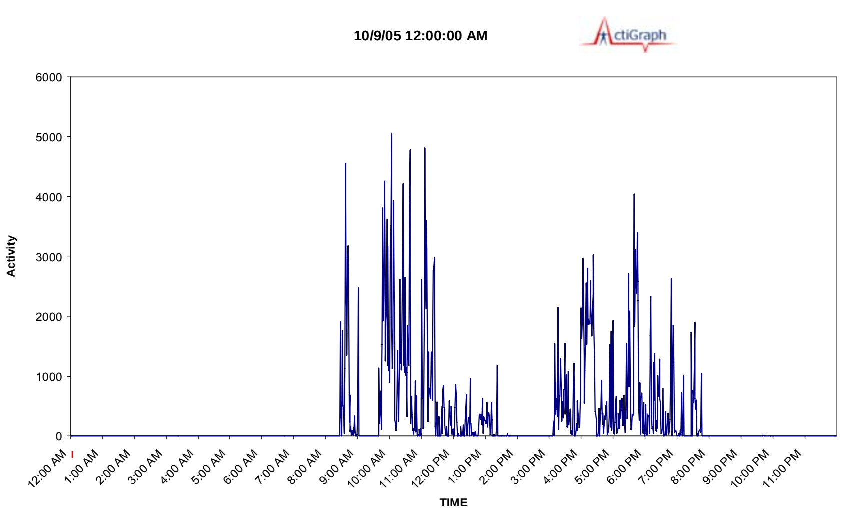
1. Total sedentary time per day, composed of duration per day spent on inactive play, TV viewing, naps and sleep at night;
2. Non sleeping sedentary time per day, composed of duration per day spent on inactive play and TV viewing;
3. Sedentary time per day for TV viewing;
4. Sedentary time per day for inactive play;
5. Vigorous time per day for vigorous activity.

Accelerometers

Data from accelerometers with the minute by minute activity counts were uploaded to a data reduction program (QBASIC) for determination of time spent on sedentary behaviour (< 1100 counts/min) and non-sedentary behaviour (≥ 1100 counts/min). The cut-off point demonstrated a high sensitivity (83%) and specificity (82%) in quantifying sedentary behaviour in children aged 3 to 4 years, and suggested that accelerometers provide an objective assessment of engagement in physical inactivity in young children (Reilly et al., 2003a).

The accelerometer graphs below illustrate how the accelerometer data assess the physical activity in one child in two days:





A valid day was defined as a day when the child wore the monitor for 8 hours or more, and periods of more than 10 minutes of consecutive zero counts were considered as non-wearing time. Only children with at least 4 valid days of more than 8 hours of wearing time, were included in the analyses. There were 77 of 83 (93%) children who met this criterion. Table 6-1 show the distribution of valid days for all children.

Table 6-1 Summary of number of children wearing the accelerometer

Valid days	Number of children who wore the accelerometers	
	n = 77	%
4	5	6.5
5	3	3.9
6	19	24.7
7	50	64.9

To be consistent with data from the questionnaires, data from the accelerometers were expressed as time (in minutes per day) for different types of sedentary behaviour and vigorous activity, as outlined below.

1. Total sedentary time per day was defined as the time spent for sedentary behaviour over the whole day including the time the child did not wear the accelerometer (sleep, nap, others). This assumed that the child only engaged in sedentary activities when he/she did not wear the accelerometer. This was calculated as the total number of minutes the accelerometer recorded data, regardless of whether or not it was worn, minus the minutes in non-sedentary activities.

2. Sedentary time per day was the time the child spent on sedentary activities while the accelerometer was actually worn. This was calculated as total minutes the accelerometer was actually worn, minus the minutes for non-sedentary activities.

3. Non-sedentary time per day was the time the child participated in some form of activity including light, moderate and vigorous activity. This was calculated as the sum of all minutes with the counts ≥ 1100.

In addition, the mean counts per day, which were calculated using only the data for the valid days, were also used in the analyses.

6.2.2 Statistical analyses

Analyses were performed using STATA version 9 (2005, Stata Corporation, College Station, TX, USA). Variables on sedentary behaviour and vigorous activity from the questionnaire were examined for missing values and outliers, and cleaned by checking the questionnaire prior to data analysis. All variables and accelerometer data were checked for normality. Descriptive results including anthropometric measurements, inactive plays and vigorous activity assessments from the questionnaire and the accelerometer were described by means and standard deviations. The Student's *t*-test and Wilcoxon rank sum test were used to compare groups for normally and non-normally distributed continuous variables.

To examine the validity of the questionnaire, the Spearman's rank correlation coefficient was used because data obtained from both the questionnaire and the accelerometers were not normally distributed. Thus, total sedentary time per day, the combined time per day for TV viewing and inactive play, the time per day for TV viewing alone, and the time per day for inactive play, as calculated from the questionnaires, were compared with total sedentary time as measured from the accelerometer (including the time the accelerometer was not worn). Non sleeping sedentary time per day for TV viewing and physical inactivity, the time for TV viewing alone, and the time for inactive play alone, were also compared with the sedentary time recorded while the accelerometer was worn. The time spent for vigorous activity per day measured by the questionnaire was correlated with the non-sedentary time recorded by the accelerometer as well as with the mean total activity counts per day.

The Bland-Altman method was employed to quantify the variability of differences between the questionnaire and the accelerometer as well (Bland and Altman, 1999). In this approach, a plot of the difference between the methods against their mean was made, allowing for a measurement of the level of agreement between the two measurements. The 95% limits of agreement was a range within which most differences between measurements by the two methods were found, and were determined as follows. Assuming a normal distribution of differences, then 95% of differences lie between:

$$\bar{u} \pm 1.96 \times S_d$$

where $\bar{u}$ was the mean difference between the measurements and S_d was the standard deviation of the differences.

6.3 Results

Characteristics of children participating in the validation study in both genders including age, weight, height, BMI and the triceps, subscapular and suprailiac skinfold thickness measurements are summarised in Table 6-2. In general, there was no significant difference in these characteristics of interest between boys and girls.

Table 6-2 Characteristics of the subjects participating in the validation study by gender

Mean, standard deviation of age, weight, height, BMI and skinfold thickness of participants by gender

Characteristics	All (n=77)		Boys (n = 39)		Girls (n = 38)		p-value[1]
	Mean	SD	Mean	SD	Mean	SD	
Age (months)	62.2	3.7	61.7	3.6	62.7	3.7	0.241
Weight (kg)	21.7	3.9	21.7	4.3	21.6	3.5	0.990
Height (cm)	111.8	4.6	111.6	5.0	112.0	4.2	0.717
BMI (kg/m^2)	17.2	2.3	17.2	2.4	17.2	2.1	0.914

[1] *p-value was calculated by Student's t-test*

Table 6-3 shows the description of physical activity of subjects using the questionnaire and the accelerometers, by gender. Since the distributions of the variables from the questionnaire and the accelerometers were not normal, they were presented as means and medians. The reported sum of different types of sedentary behaviour, such as total sedentary time in a day, and sedentary time for TV viewing combined with time for inactive play, was not significantly different between the genders. Girls appeared to spend more time for inactive play compared with boys, however, the p-value was slightly above the 5% significant level (p=0.0598). In contrast, the time boys participated in vigorous activity was significantly higher than that for girls (p=0.0013). The evaluation of physical activity from accelerometers showed similar patterns in sedentary behaviour and vigorous activity to that reported by teacher and parents. Girls spent more time in sedentary behaviour than boys, whereas boys spent more time in non-sedentary behaviour than girls. However, the gender differences in physical activity measured by the accelerometer were not statistically significantly different. As can be seen from Table 6-3, total sedentary time in a day, reported by teacher and parents was underestimated compared with that measured by the accelerometers.

Table 6-3 Descriptive data on different types of sedentary behaviour and vigorous activity obtained from two methods, by gender

Mean, median and inter-quartile range (IQR) of physical activity data obtained from two methods

Physical activity per day	All (n=77)			Boys (n = 39)			Girls (n = 38)			p-value[1]
	Mean	Median	IQR	Mean	Median	IQR	Mean	Median	IQR	
Proxy questionnaires										
Total sedentary time (min)	948.9	942.9	112.2	950.8	930.0	141.4	946.9	950.6	88.6	0.943
Non sleeping sedentary time (TV viewing + inactive play) (min)	209.4	188.6	132.9	200.1	162.9	128.6	219.0	207.9	114.0	0.255
TV viewing (min)	85.5	54.2	66.3	90.9	72.9	89.6	80.0	61.3	61.3	0.414
Inactive play (min)	123.9	102.9	106.3	109.2	81.4	56.0	139.0	132.0	124.3	0.058
Vigorous time (min)	79.1	61.7	65.1	91.7	94.3	48.0	66.1	44.6	41.1	0.001
Accelerometer										
Sedentary time (including time not worn) (min)	1302.9	1312.2	78.0	1292.6	1301.3	77.3	1313.5	1315.8	67.4	0.079
Sedentary time (excluding time not worn) (min)	558.8	564.1	109.3	544.2	546.7	108.9	573.7	588.0	126.7	0.108
Non sedentary time (min)	136.8	127.6	78.2	147.1	138.5	75.1	126.2	123.0	67.4	0.074
Total counts (Kcounts)	442.5	434.1	152.5	465.3	456.3	171.1	419.2	398.7	165.3	0.079

[1] p-value was calculated by Wilcoxon rank sum test

Table 6-4 looks at the reported time the child engaged in sedentary behaviour on a typical weekday and weekend day. The sum of time spent on different types of sedentary behaviour on a typical weekday such total sedentary time and non sleeping sedentary time, was not significantly different from that of a typical weekend day (p=0.1469 and p=0.3914 respectively). During weekdays, children spent less time viewing TV than they did on a weekend day (p < 0.0001). However, children were reported to participate in inactive play on weekdays significantly more than on weekend days. In contrast, they were observed to engage in vigorous activity more often on a typical weekend day than on a typical weekday (p<0.0001).

Table 6-4 Reported physical activity on a typical weekday and weekend day

Mean, median and inter-quartile range (IQR) of reported physical activity on a typical weekday and weekend day

Physical activity per day in minutes	In a day			Weekday			Weekend day			p-value[1]
	Mean	Median	IQR	Mean	Median	IQR	Mean	Median	IQR	
Proxy questionnaires										
Total sedentary time	948.9	942.9	112.2	928.8	930.0	150	958.8	950.6	120	0.146
Non sleeping sedentary time	209.4	188.6	132.9	197.9	180	150	210.8	210	150	0.391
TV viewing	85.5	54.2	66.0	67.8	60.0	51.6	118.4	120.0	67.1	0.000
Inactive play	123.9	102.9	62.9	130.1	90.0	67.1	92.3	60.0	65.5	0.000
Vigorous time	108.6	98.6	45.2	99.6	90.0	46.0	135.0	120.0	68.0	0.000

[1] *p-value was calculated by Wilcoxon rank sum test*

Table 6-5 presents the spearman's correlation coefficients for reported sedentary behaviour time on a typical day, compared with sedentary behaviour time recorded by accelerometer used for different periods of time. Higher correlation coefficients were found when reported physical activity was compared with scores from seven days of accelerometer recordings. The correlation coefficient for inactive play on an average day reached the highest value when correlated with the scores from four to seven days of accelerometer use (r = 0.1980, p=0.0844; r = 0.2775, p=0.051 respectively). Lower coefficients were found for the sum of the time spent on inactive play and TV viewing on an average day (r = 0.16, p=0.1644; r = 0.2480, p=0.0825 for ≥ 4 and 7 days respectively). Parental reports of TV viewing on an average day correlated less with sedentary behaviour time from the accelerometer.

Table 6-5 Correlation between sedentary time reported and during accelerometer use

Spearman correlation coefficients between reported sedentary behaviour time and sedentary time from accelerometry counts excluding the time the accelerometer was not worn

	Sedentary time excluding time not worn (min/day)			
	Wearing ≥ 4 days		Wearing =7 days	
Physical activity from questionnaire (min/day)	Spearman correlation coefficients	p-value	Spearman correlation coefficients	p-value
Inactive play	0.1980	0.0844	0.2775	0.051
TV viewing time	0.0301	0.7950	0.0919	0.525
Non sleeping sedentary time (TV viewing + quiet play)	0.1600	0.1644	0.2480	0.082

Table 6-6 presents the correlation coefficients for reported sedentary behaviour time compared with the accelerometer score for sedentary behaviour time, including the time the accelerometer was not worn. Accelerometer data collected from at least four days and seven days of recording were correlated with sedentary behaviour from the questionnaire. The reported total sedentary time on a typical day was found to produce the highest correlation coefficient with the accelerometer data for at least fours days and seven days of accelerometer use (r = 0.132, p=0.252; r = 0.2865, p=0.043 respectively). Lower and nonsignificant correlation coefficients were observed for reported non-sleeping sedentary time and inactive play compared to data from the accelerometers (r = 0.1991, p=0.165; r = 0.2276, p=0.111 respectively). Reported TV viewing was shown to least correlate with total sedentary time as assessed by the accelerometers with 4 to 7 days of recording (r = 0.0657, p=0.57; r = 0.0509, p=0.725 respectively).

Table 6-6 Correlation between sedentary time reported and accelerometer score

Spearman correlation coefficients between reported sedentary behaviour time and sedentary time from accelerometry counts including the time the accelerometer was not worn

	Sedentary time including time not worn (min/day)			
	>= 4 days of wearing		7 days of wearing	
Physical activity from questionnaire (min/day)	Spearman correlation coefficients	p-value	Spearman correlation coefficients	p-value
Total sedentary time	0.132	0.2525	0.2865	0.043
Non sleeping sedentary time (TV viewing + quiet play)	0.1264	0.2734	0.1991	0.165
Inactive play	0.0851	0.4620	0.2276	0.111
TV viewing time	0.0657	0.5700	0.0509	0.725

Table 6-7 reveals the correlation coefficients between reported vigorous activity on a typical day and mean total activity counts per day and non-sedentary time from accelerometer with at least 4 days and 7 days of wearing. A higher correlation coefficient was seen for the comparison of reported vigorous activity with the mean total counts per day assessed by the accelerometer with 4 and 7 days of wearing, however, it is not statistically significant (r = 0.1494, p=0.201; r = 0.1722, p=0.236 respectively). Similarly, a low and statistically insignificant correlation coefficient was found for reported vigorous activity in a day compared with non-sedentary time measured by the accelerometer with 4 and 7 days of wearing (r = 0.1116, p=0.341; r = 0.0926, p=0.527 respectively).

Table 6-7 Correlation between vigorous activity reported and accelerometer score

Spearman correlation coefficients between reported vigorous activity and mean total activity counts per day and non-sedentary time from accelerometer

	≥4 days of wearing		7 days of wearing	
Accelerometer data	Spearman correlation coefficients	p-value	Spearman correlation coefficients	p-value
Total counts per day	0.1494	0.2009	0.1722	0.236
Non sedentary time (min/day)	0.1116	0.3406	0.0926	0.526

Figure 6-1 shows the mean difference in total sedentary behaviour time between the two measurements was 354.0 minutes and the regression line for the total sedentary time indicated a significant linear trend ($p<0.001$). The limits of agreement between the two methods were 140.4 to 547.6, and compared to total sedentary time from the accelerometer, the limits of agreement were much wider than 2 standard deviations. The width of limits of agreement could not be interpreted. Since at the low average of sedentary behaviour they were too large, and at the high average of sedentary behaviour, they were too small. However, the pattern in the graph did not improve after log-transformation (Figure 6-2), suggesting that the limits of agreement are difficult to interpret.

Figure 6-1 Bland-Altman method plot of total sedentary behaviour

Bland-Altman method plot of total sedentary behaviour reported from questionnaires versus from the accelerometer including the time it was not worn

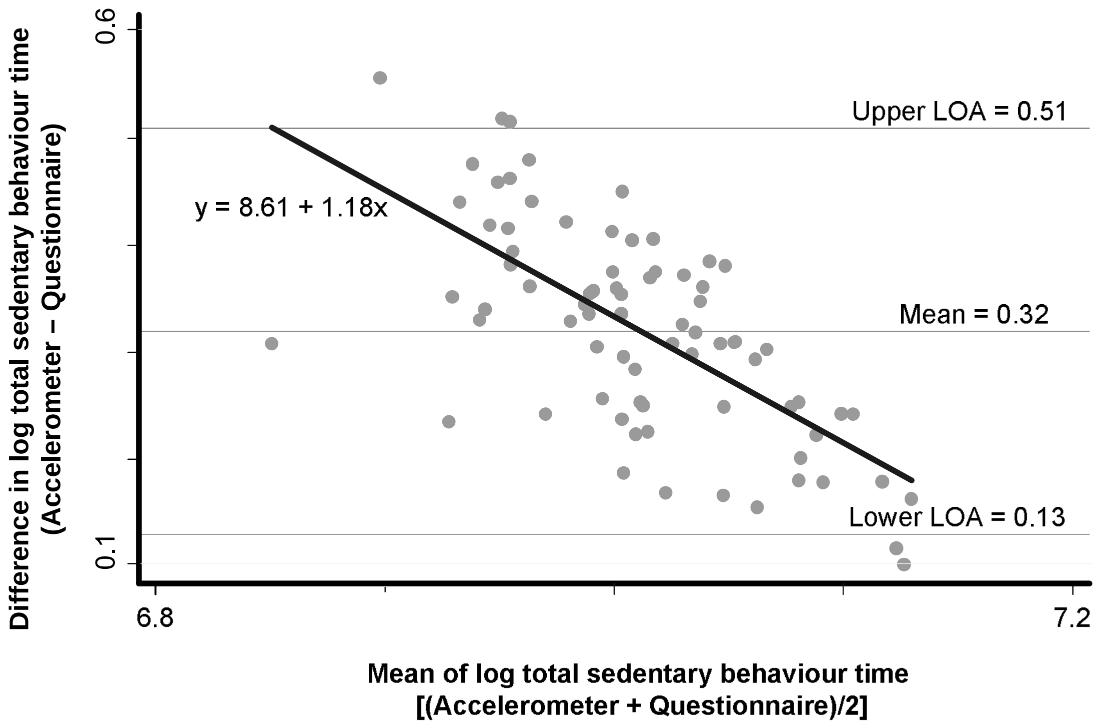


Figure 6-2 Bland-Altman method plot of log total sedentary behaviour

Bland-Altman method plot of log total sedentary behaviour reported from questionnaires versus from the accelerometer including the time it was not worn

Figure 6-3 shows the mean difference in sedentary time between the two methods in which reported sedentary behaviour time for TV viewing and inactive play were compared with sedentary behaviour time assessed by the accelerometer, not including the time the accelerometer was not worn. As can bee seen from this plot, the mean difference was 349.3 minutes and the regression line did not indicate a significant trend (p=0.661). The limits of agreement for this sedentary behaviour were 137.3 to 561.4. This range of values was wider than 2 standard deviations of sedentary time from the accelerometer, implying a poor agreement. The graph reveals no clear pattern for the differences in sedentary time from the two measurements.

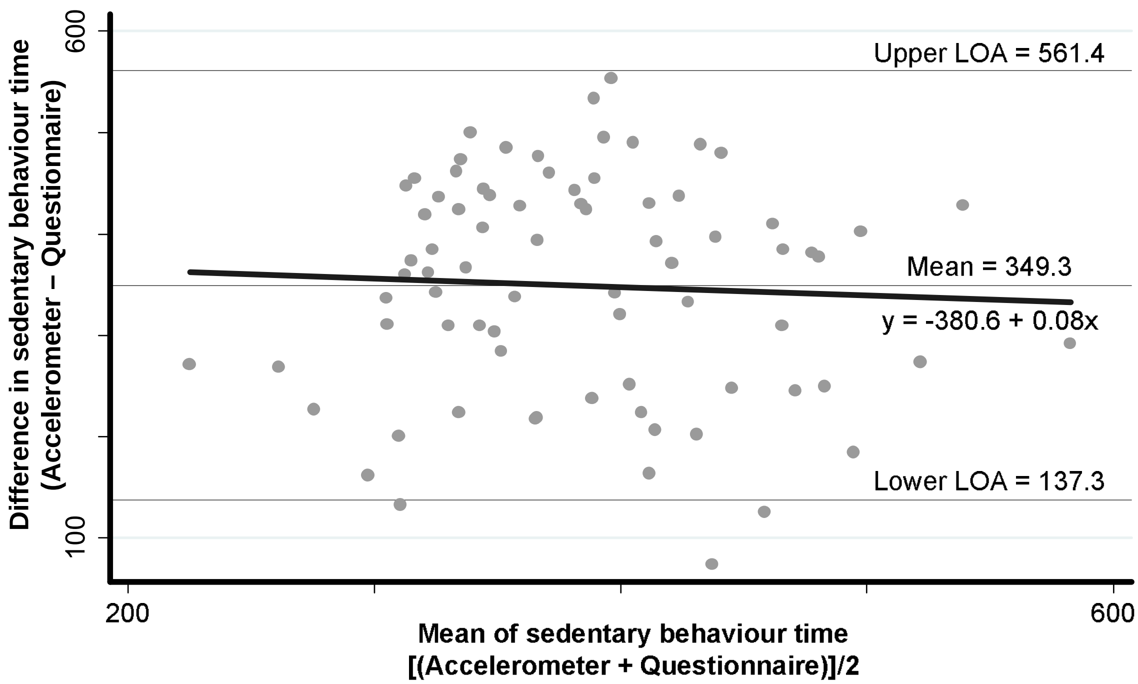


Figure 6-3 Bland-Altman method plot of sedentary behaviour for TV viewing and inactive play

Bland-Altman method plot of sedentary behaviour for TV viewing and inactive play reported from questionnaires versus from the accelerometer during the time it was worn

6.4 Discussion

In this study, the combination of teacher and parents' reports in assessing physical activity of children aged four to five years demonstrated modest capacity of the questionnaire to validly rank the children by level of sedentary behaviour when compared to the accelerometry scores. However, the questionnaires performed poorly for vigorous activity with low validity for ranking the children by level of vigorous activity compared to the accelerometer scores. These proxy questionnaires have shown to be not suitable for measuring the absolute level of physical activity of young children. They underestimate the child's sedentary behaviour compared with the accelerometry scores.

This proxy questionnaire has focused on measuring a number of sedentary behaviours such as TV viewing, inactive play, nap and sleep time at night, and vigorous activity in preschool children. The physical activity, recorded over a three month period, aimed to characterise the usual physical activity of children. The correlation coefficient between the questionnaires and the accelerometer scores improved with data recorded during seven valid days of accelerometer use compared with only at least four valid days. Seven day monitoring has been suggested as a sensible choice for youth and is more likely to achieve a higher reliability (Trost et al., 2005), because it will better represent a child's long term physical activity behavior. Another possible explanation is that the questionnaires were better completed by parents of those with a higher compliance of accelerometer use. However, since there were only 65% of children with data from the accelerometer for seven valid days, excluding the cases with fewer than 7 valid days may result in a selection bias.

There was some evidence to suggest that the proxy was useful for assessing sedentary behaviour time. The sum of different types of sedentary behaviour reported by both teacher and parents were shown to be significantly correlated compared with the correlations for each type of sedentary behavior ($r = 0.287$, $p=0.044$) (Table 6-6). Similar correlation coefficients were seen for the reported inactive play and non sleeping sedentary time given by both the teacher and the parents ($r = 0.278$, $p = 0.051$; $r = 0.248$, $p=0.082$ respectively). There have been few studies specifically designed to measure the validity of a proxy questionnaire in assessing sedentary behaviour such as inactive plays and TV viewing (Bryant et al., 2007). Although TV viewing was employed as a proxy of sedentary behaviour in most studies investigating determinants of childhood obesity, it has been recognised that there is a lack of a reliable and valid method for assessing TV viewing for use in epidemiological studies, since direct observation, the gold standard for TV measurement (Bryant et al., 2007), is not feasible. A study assessing the validity of tools to measure TV viewing in children aged 8 to 9 years, using direct observation as a criterion, reported correlations ranging from r = 0.07 for child self-report to r = 0.39 for parental report (Borzekowski and Robinson, 1999, Bryant et al., 2007). The self-report form used to interview both mother and children in this study was developed to measure TV viewing only, with questions on time spent for different types of watching separately for weekdays and weekend days such as watching regular TV programs and watching videotapes (Borzekowski and Robinson, 1999).

Other studies examining the validity of TV viewing against an objective measure have compared TV viewing with intense physical activity rather than a measure of inactivity and reported negative correlation coefficients. Validity coefficients for reported TV viewing in children aged 4 to 7 years against total activity and vigorous activity measured by the accelerometer were found to be -0.16 ($p<0.05$) (Janz et al., 2005). However, this approach has been criticised as being insufficient, in terms of assessing the true validity of the measure, because participation in intense physical activity might be compensated for by an increased amount of sedentary behavior (Epstein et al., 2005).

In the study reported here, using the cut-off points for accelerometry output to quantify the time spent on sedentary behavior, different types of sedentary behavior were compared with a criterion measure for inactivity. Nevertheless, among types of sedentary behaviour, reported average daily times for TV viewing by weighting the weekend and weekdays was shown to have the lowest correlation coefficient (r = 0.05 – 0.09). Perhaps the question, with the quantitative response format used in this proxy questionnaire, is unable to capture TV viewing time in children.

Furthermore, measurement error related to memory and social desirability bias is not uncommon in this type of self-report. In a comparison of parental reported TV viewing and child self-report, parents were seen to consistently underestimate the amount of time their child watched TV (Armstrong et al., 1998, Saelens et al., 2002). It has been suggested that a tool developed to exclusively measure TV viewing would play an important role in studies focusing on TV viewing (Bryant et al., 2007). Additionally, more information such as the type of TV program and the reason that the child stopped viewing has been suggested as being useful when parental reporting is employed (Bryant et al., 2007).

Most of the investigations have examined the measurement properties of the proxy questionnaire regarding the assessment of higher levels of physical activity such as moderate and vigorous activity. The findings of these studies vary from poor to some high validity. Physical activity with moderate to vigorous intensity in children aged 4 to 8 years reported by teacher and parents moderately correlated with a heart rate monitor and Caltrac accelerometer, with r = 0.40 and r = 0.53 respectively (Harro, 1997). Similarly, parents' records of moderate to vigorous physical activity during leisure activity in children aged 6 years, over three days, was found to have significantly high correlation with physical activity measured by a heart rate monitor, with the values ranging from 0.72 to 0.82 for each of three days reported. More variable correlation coefficients have been observed for reported physical activity given by teachers, where the values ranged from 0.07 to 0.59 for weekend days and school days (Manios et al., 1998). However, the questionnaires used in both these studies were similar to diary, as parents and teachers were asked to observe and record the child's physical activity level during the time the criterion measures were employed. This might result in more attention by parents and teachers in reporting the child's activity. Furthermore, information from these proxy reports did not rely on the proxy reporter's memory since the child's physical activity was recorded over a number of days. In contrast, a validation study of a proxy questionnaire given by a check list for 30 types of moderate to vigorous activities, to measure usual physical activity in children aged 5 to 6 years, demonstrated low correlations with data from accelerometers ($r = -0.06$ – 0.05) (Amanda et al., 2004).

In the present study, there was a slightly higher coefficient for reported vigorous activity given by both teacher and parents compared to the mean counts per day; however, this was not statistically significant ($r = 0.1722$, $p=0.2367$). It is known that the activity of young children is characterised by less structured, intermittent, and transitory activity (Welk et al., 2000). Therefore, proxy-reporters, including parents and teachers, might be unable to accurately estimate their children's activity because their time throughout the day for observing the child is limited. This may explain the unsatisfactory correlation coefficients for reported physical activity compared with that assessed by the criterion method.

There were a number of weaknesses in this study that might affect the validity and limit the evaluation of the proxy questionnaires in assessing physical activity in this child population. Firstly, this proxy-questionnaire focused only on a number of types of sedentary behavior and vigorous activity in this age group, and there are other types of free-play activity that were not recorded. For example, physical activity outside of preschool and home are not recorded such as physical activity in primary school preparation class and sport courses. This may have resulted in an underestimation of physical activity from the questionnaire. This may result in the underestimation of physical activity from the questionnaire. Additionally, this questionnaire did not include questions measuring light and moderate physical activity.

With regard to the format of the questionnaire, the questions used to obtain the information on physical activity were designed using a quantitative response format on an ordinal scale, with the thought that it might be less burdensome for the respondents; however, this might have resulted in a loss of information. These findings have underlined the difficulties in seeking a valid proxy-questionnaire for assessing children's physical activity.

Although the accelerometer has been considered to be an objective instrument that can be used as a criterion method in validation of a subjective method to measure physical activity (Kohl et al., 2000), it has been recognised as underestimating physical activity because it has a limited ability to assess cycling, locomotion on a gradient such as walking or running up hills, or aquatic activities such as swimming (Sirard and Pate, 2001). Additionally, short epoch settings such as 5 to 15 seconds have been suggested as being of significant importance when interpreting the output from accelerometers when used in children. This is especially important in young children because a more detailed picture of physical activity intensity patterns can be captured when a shorter sampling interval is used than when a 60-second setting is used. Young children are known to have sporadic, short bursts of vigorous activity (Nilsson et al., 2002) which might not be captured with a longer sampling interval. Therefore, a one minute epoch setting for the accelerometer, as used in this study may lead to an underestimation of moderate and vigorous activity while overestimating sedentary behaviour. This weakens any conclusion for the validity of vigorous activity. Finally, the accelerometers are not able to assess TV viewing but generally assign as sedentary time, while the questionnaire asks about a number of specific sedentary activities, including watching TV.

The use of two definitions for sedentary time recorded by the accelerometer, including and excluding the time it was not worn, is another limitation of this study. With regard to the former definition, the assumption that the child only engaged in sedentary activities when he/she did not wear the accelerometer may overestimate the sedentary behaviour time.

The time of collecting data from both methods did not exactly match and so that may have effects on the findings of this study. Data collection using the accelerometer was carried out over a four months while data of from the questionnaires was collected in the middle of this period of time. Children with accelerometry data collected before the questionnaire was collected were more likely to have data with higher correlation between both methods compared with data from the accelerometers after the reported physical activity was collected. Furthermore, the questionnaire captured the usual physical activity over the three preceding months whilst the accelerometer captured the physical activity over one week and that might not have been a typical week of physical activity for that child. This may result in a lack of agreement between data collected from both methods. Finally, test-retest reliability of this proxy-questionnaire was not examined.

In summary, this validation study is the first study aiming to validate a proxy-questionnaire of physical activity for use with preschool children in HCMC. This proxy-questionnaire was shown to have limitations in measuring physical activity in this child population. There was some evidence to demonstrate a modest capacity of the questionnaire to give a valid rank for children by level of sedentary behaviour, including total sedentary behaviour and inactive play, when compared with the accelerometry scores. However, the correlations for other types of sedentary behaviour such as TV viewing and vigorous activity were weak.

The findings suggest that this proxy-report is acceptable for use when ranking children by their physical activity but the findings need to be interpreted with caution due to the limitations addressed above. Given that the proxy-questionnaire has been shown to be a viable assessment technique in measuring physical activity in children on a large-scale population (Janet et al., 2001, Sirard and Pate, 2001), this study highlights the need for more work to improve the proxy-questionnaire and the need to test it again with a validation study of improved design. The items to measure light and moderate physical activity and other types of physical activity outside the preschool and home settings, such as in primary school preparation class, should be included in the questionnaire. A shorter sampling interval (5 to 15 seconds) for accelerometers, would be useful in providing a more detailed picture of the physical activity intensity patterns in this child population.

Chapter 7 Dietary intake patterns

7.1 Introduction

During recent decades, there has been a major concern that shifts in dietary structure are contributing to the development of childhood obesity in Asian nations such as China, Thailand and Malaysia (Drewnowski and Popkin, 1997, Kosulwat, 2002, Noor, 2002). The proportion of energy derived from complex carbohydrates has diminished sharply while the proportion of energy derived from sugar and animal fats has increased (Drewnowski and Popkin, 1997). These changes in dietary structure, as well as changes in physical activity patterns, are thought to be responsible for an increasing prevalence of non-communicable diseases such as diabetes and cardiovascular disease in these countries (Popkin, 2003).

The structure of the Vietnamese diet has also changed markedly during the past two decades. The average daily intake of animal products, especially meat, has increased considerably from 24 grams/ day in 1990 to 51 grams/ day in 2000 and the percentage of energy from fat has risen from 6% in 1990 to 12% by 2000 and in many urban groups, the figure has exceeded 20% (Khoi and Khan, 2004).

In addition to the changes in diet structure, changes in disease patterns have also been observed. There has been a significant improvement in the levels of malnutrition in Vietnamese children over the past few decades. At the same time over-nutrition in children and adults, and an increase in non-communicable diseases, have emerged in urban populations (Khoi, 2002).

Young children have the highest nutritional demands and a balanced diet in childhood is very important to ensure optimum growth and development (Glynn et al., 2005). Recently, there has been growing evidence that childhood diet may have important implications for the development of chronic disease in later life. Studies examining the early natural history of heart disease have concluded that adult cardiovascular disease begins in childhood. The relationship between early dietary habits such as high intake of fat and energy and the subsequent development of cardiovascular disease, has already been demonstrated (Berenson et al., 1995, Berenson et al., 1998). Several longitudinal studies have found an association between early protein intake and changes in body fatness later in life, generating an hypothesis that protein consumption in early childhood may lead to the later development of obesity (Rolland-Cachera et al., 1995, Skinner et al., 2004). Thus, the assessment of dietary intake is essential for monitoring the nutritional status of preschool child populations, as well as for conducting epidemiologic research on the association between diet and health in this age group (Serdula et al., 2001).

There is growing evidence now that obesity has become a public health problem in urban adolescent and adult populations in Ho Chi Minh City (HCMC), Vietnam (Loan et al., 2003a, Cuong, 2004, Hong, 2005). There is increasing interest in studying the influence of food consumption in predisposing obesity in these populations. Among primary school children in a wealthy urban districts of HCMC, higher total caloric and fat intake, greater consumption of sweets but lower consumption of fruit and vegetables were found in overweight children, compared with their peers who were of normal weight (Loan et al., 2003a). The comparison of nutrient intake with the RDA (NIN, 2007) for children in this age group showed that the total energy intake met the recommendations; however, the percentage of energy from fat and from protein, were higher than recommended (Loan et al., 2003a).

Little is known about what preschool children in HCMC eat or how well their nutrient intake meets nutrient recommendations. The amount and type of food intake in early childhood has been shown to have implications for long-term health outcomes (Berenson et al., 1995, Berenson et al., 1998). An assessment of dietary intake in this young child population, which appears to be experiencing an obesity epidemic, would provide important information to help understand the rapid changes observed in their nutritional status. The aim of this chapter is to describe the nutrient intake and food patterns of preschool children aged four to five years, based on the baseline data of the cohort study, and compare these nutrient intakes with the recommendations for Vietnamese children of this age.

7.2 Methodology

Data were obtained from the baseline measurement of the one year cohort study. The survey methods and dietary assessment for this study have been described in detail in Chapter 3. The FFQ used to collect the dietary information examined in this chapter can be found in the Appendix 1.

7.2.1 Data analysis

The proportion of children with energy intake from macronutrients meeting or exceeding the recommendations, was estimated based on the 2007 RDA for Vietnamese children in this age group, to approximate the estimated average requirements (NIN, 2007). The approach recommended for evaluating the adequacy of nutrient intakes of population groups is using the estimated average requirement (EAR), with two methods based on the EAR such as the probability approach and the EAR cutpoint method (Gibson, 2005b). However, they require the estimated average requirements for nutrients that is not always specified in some tables of nutrients such as the one in Vietnam. Therefore an alternative method suggested is the use of 77% of the RDA as a cutoff value (Gibson, 2005b). The approximations for the mean nutrient requirements relied on the assumption that the 2007 RDA estimates the mean requirement plus two standard deviations, with a coefficient of variation of 15%. Such assumptions yield a conservative estimate of nutrient inadequacy compared with that based on a coefficient of variation for the nutrient of 10% (Gibson, 2005). Mean nutrient requirements were then calculated as 77% of the 2007 RDA. The total energy intake was compared with the age specific 2007 RDA and the adequacy of nutrient intakes were determined by total intakes at or above 77% cut off of the 2007 RDA, for the whole studied population and specific child groups. The RDAs for energy intake and the RDAs (and 77% cut points) nutrient intakes for children at this age were used, as presented in Table 7-1. The recommended ranges for the percentage of energy from protein, fat and carbohydrate are 12% to 14% (≥ 50% of energy intake), 18% to 25% (70% vegetable fat: 30% animal fat) and 61% to 70%, respectively.

Table 7-1 Energy intake, percentage of energy from macronutrients, and nutrient intake for children 4 to 6 years old according to the 2007 RDAs and 77% of RDA cut off values

Energy intake and nutrients	RDAs	77% of RDA cut off values
Energy (kcal)	1470	NA
Protein (g)	44-55	33.9
Vitamin A (mcg)	450	346.2
Vitamin B1 (mg)	0.6	0.46
Vitamin B2 (mg)	0.6	0.46
Vitamin B3 (mg)	8.0	6.15
Vitamin C (mg)	30	23.1
Calcium (mg)	600	461.5
Iron (mg)	8.4	6.46
Zinc (mg)	5.1	3.90

NA Not available

7.2.2 Statistical analyses

Statistical analyses were conducted using STATA version 9 (2005, Stata Corporation, College Station, TX, USA). The Stata "svyset" commands were used to adjust the analyses for the stratified two-stage cluster sampling design using Taylor linearized variance estimation. Sampling weights for each stratum used in this study are presented in detail in Chapter 3.

All nutrients were checked for normality and log-transformation was performed for non-normally distributed nutrients. Group means and 95% confidence intervals for each nutrient by gender, household wealth index, place of residence, and parental education levels were calculated. Student's t-test was used to compare two groups of normally distributed continuous data. The one-way ANOVA Bonferroni procedure and the Kruskal-Wallis test were employed for comparison of three or more group means of normally and non-normally distributed continuous data, respectively.

7.3 Results

In the baseline study, 697 children and their parents agreed to participate with the parents/caregivers and teachers of 670 children completing the FFQ interviews. The parents/caregivers of 22 children were not available on two clinic days at selected preschools. The remaining 5 participants with missing anthropometry and socioeconomic data were excluded. No participant was excluded because of implausible energy intake being reported. Thus, the response rate for this study was 95.7%.

Table 7-2 shows the description of nutrient intake in absolute values as well as the percentage of energy from macronutrients, in boys and girls combined and separately. Energy intake and nutrient intake were normally distributed except for zinc, which required a log-transformation for further analysis. In general, there was a gender difference in nutrient intake, where boys were observed to have higher nutrient intake than girls. The intake of protein, fat and carbohydrates was greater for boys than for girls, although the p-value for fat was only of borderline significance (p=0.0516). Therefore, total energy intake for boys was higher than for girls (p=0.0047). Boys consumed more animal and vegetable protein than girls (p=0.0256 and p=0.0180 respectively), whilst the higher fat consumption of boys came from animal fat rather than vegetable fat (p=0.0560). However, the percentage of energy from protein, fat and carbohydrates were not significantly different between boys and girls. Fibre consumption was similar for both genders. With regard to micronutrients, significantly greater vitamin B2, calcium and phosphorus intakes were found for boys compared with girls. There was no significant difference in vitamin A, vitamin B1, vitamin B2, magnesium, iron, and zinc intake between boys and girls.

Table 7-2 Mean nutrient intake by gender

Mean and 95% confidence interval for energy intake, nutrient intakes and the percentage of energy from macronutrients by gender in children aged 4 to 5 years

Nutrients		Total (n = 670)		Boys (n = 333)		Girls (n = 337)		p-value[1]
		Mean	95% CI	Mean	95% CI	Mean	95% CI	
Energy (kcal)		1602.0	1570.0, 1634.0	1646.0	1598.0, 1694.0	1559.0	1526.0, 1593.0	0.004
Protein								
	Grams	73.9	72.6, 75.2	75.7	73.9, 77.5	72.1	70.4, 73.8	0.011
	% kcal	18.5	18.2, 18.7	18.4	18.1, 18.7	18.5	18.2, 18.7	0.841
Animal protein								
	Grams	47.9	46.7, 49.0	49.0	47.6, 50.4	46.7	45.3, 48.1	0.025
	% kcal	12.0	11.7, 12.2	12.0	11.6, 12.3	12.0	11.6, 12.3	0.732
Vegetable protein								
	Grams	25.8	25.1, 26.5	26.5	25.5, 27.4	25.1	24.2, 25.9	0.018
	% kcal	6.4	6.3, 6.5	6.4	6.3, 6.5	6.4	6.3, 6.6	0.655
Fat								
	Grams	38.4	37.1, 39.6	39.3	37.6, 40.9	37.5	36.3, 38.6	0.051
	% kcal	21.4	20.9, 21.9	21.3	20.8, 21.9	21.4	20.8, 22.0	0.749
Animal fat								
	Grams	26.4	25.3, 27.5	27.0	25.7, 28.3	25.8	24.7, 26.9	0.056
	% kcal	14.8	14.2, 15.4	14.8	14.2, 15.3	14.8	14.1, 15.5	0.867
Vegetable fat								
	Grams	11.8	11.3, 12.3	12.1	11.3, 12.8	11.5	10.8, 12.2	0.183
	% kcal	6.5	6.2, 6.7	6.5	6.2, 6.8	6.5	6.2, 6.8	0.840
Carbohydrate (g)								
	Grams	241.0	235.0, 246.0	248.0	240.0, 256.0	234.0	227.0, 240.3	0.002
	% kcal	60.3	59.0, 60.0	60.3	59.0, 61.0	60.3	59.0, 61.0	0.885
Fibre								
	Grams	6.5	6.3, 6.7	6.7	6.3, 7.0	6.3	6.0, 6.6	0.122
Vitamin A								
	Micrograms	753.0	723.0, 782.0	762.0	726.0, 798.0	743.0	708.0, 778.0	0.405
Vitamin B1								
	Milligrams	1.38	1.34, 1.41	1.41	1.36, 1.45	1.35	1.31, 1.39	0.068
Vitamin B2								
	Milligrams	1.57	1.52, 1.61	1.61	1.55, 1.66	1.50	1.47, 1.58	0.017
Vitamin B3								
	Milligrams	13.12	12.83, 13.42	13.3	13.09, 13.58	14.0	13.52, 14.49	0.106
Vitamin C								
	Milligrams	132.0	127.0, 138.0	137.0	128.9, 145.9	128.2	122.0, 134.0	0.101
Calcium								
	Milligrams	902.0	867.0, 936.0	937.0	893.4, 980.9	867.0	838.0, 897.0	0.003
Magnesium								
	Milligrams	179.0	174.0, 184.0	181.0	175.9, 187.3	176.0	170.2, 183.4	0.126
Phosphorus								
	Milligrams	998.0	970.0, 1026.0	1024.0	988.0, 1060.0	973.0	945.6, 1000.9	0.011
Fe								
	Milligrams	13.7	13.3, 14.1	13.9	13.3, 14.5	13.46	13.0, 13.8	0.107
Zn								
	Milligrams	8.17	7.75, 8.58	8.23	7.7, 8.7	8.11	7.5, 8.6	0.291

[1] p-value was calculated from Student's t-test

The mean energy intake and macronutrient intakes for children of both genders from wealthy and less wealthy districts are presented in Table 7-3. Overall, greater energy intake and macronutrient intake including protein, carbohydrate and fibre, were found for children from wealthy districts compared with children from less wealthy districts.

Table 7-3 Mean energy intake and macronutrient intake by gender from wealthy and less wealthy districts

Means and 95% confidence interval for energy intake and macronutrients in children aged 4 to 5 years by gender from wealthy and less wealthy districts

Macronutrients		Wealthy areas (n = 330)		Less wealthy areas (n = 340)		p-value[1]
		Mean	95% CI	Mean	95% CI	
Energy (kcal)	Total	1654.0	1611.0, 1697.0	1575.0	1527.0, 1623.0	0.011
	Boys	1699.0	1644.0, 1753.0	1618.0	1544.0, 1692.0	0.066
	Girls	1609.0	1541.0, 1677.0	1533.0	1490.0, 1576.0	0.078
Protein (g)	Total	76.8	74.4, 79.1	72.4	70.6, 74.2	0.003
	Boys	79.1	76.4, 81.8	73.9	71.4, 76.4	0.013
	Girls	74.4	68.9, 76.3	70.9	68.7, 73.0	0.101
Animal protein (g)	Total	50.1	48.3, 51.9	46.7	45.0, 48.3	0.002
	Boys	51.8	49.5, 54.0	47.5	45.5, 49.5	0.004
	Girls	48.4	45.9, 51.0	45.8	43.9, 47.8	0.110
Vegetable protein (g)	Total	26.4	25.0, 27.8	25.5	24.5, 26.4	0.018
	Boys	27.1	25.3, 28.8	26.2	24.8, 27.5	0.262
	Girls	25.8	24.2, 27.4	24.8	23.6, 25.9	0.185
Fat (g)	Total	39.1	37.9, 40.4	37.9	36.0, 39.8	0.180
	Boys	40.0	38.4, 41.7	38.8	36.2, 41.5	0.359
	Girls	38.3	36.7, 39.9	37.0	35.4, 38.7	0.347
Animal fat (g)	Total	27.2	26.2, 28.2	26.0	24.2, 27.7	0.075
	Boys	27.9	26.7, 29.1	26.6	24.5, 28.6	0.153
	Girls	26.5	25.1, 27.8	25.4	23.8, 27.0	0.272
Vegetable fat (g)	Total	11.8	10.7, 12.9	11.8	11.1, 12.4	0.973
	Boys	12.0	10.6, 13.3	12.1	11.1, 13.2	0.745
	Girls	11.6	10.5, 12.8	11.4	10.5, 12.4	0.719
Carbohydrate (g)	Total	249.0	242.0, 256.0	236.0	228.0, 245.0	0.005
	Boys	256.0	247.0, 265.0	243.0	231.0, 256.0	0.063
	Girls	242.0	231.0, 253.0	229.0	221.0, 237.0	0.038
Fibre (g)	Total	6.8	6.4, 7.2	6.3	6.1, 6.6	0.017
	Boys	6.9	6.3, 7.4	6.6	6.1, 7.0	0.334
	Girls	6.7	6.2, 7.3	6.1	5.7, 6.4	0.015

[1] p-value was calculated from Student's t-test

Fat consumption was not significantly different between both groups of districts. A significantly higher animal protein intake by boys from wealthy districts contributed to the greater intake of protein compared with that of children from less wealthy districts observed in this child population. Protein intake by girls from both groups of districts was not significantly different. In contrast, differences in carbohydrate and fibre intake between wealthy and less wealthy districts were from higher intake of these nutrients in girls rather than boys from wealthy districts.

Table 7-4 presents a description of micronutrient intake in children by gender and groups of districts. There were similar patterns in micronutrient intake in children from wealthy and less wealthy districts as seen for macronutrient intake. Children from wealthy districts had greater intake of vitamin B1, B2 and B3, calcium, magnesium, phosphorus and zinc compared with children from less wealthy districts, although the p-value for zinc intake was of borderline significance (p=0.059). Children of both genders from wealthy districts were shown to have higher intake of these nutrients than their peers in less wealthy districts, except for vitamin B3 and zinc. Vitamin A, vitamin C and iron intake was not significantly different between both groups of districts.

Table 7-4 Characteristics of micronutrient intake by gender from wealthy and less wealthy districts

Means and 95% confidence intervals for selected micronutrients in children aged 4 to 5 years by gender from wealthy and less wealthy districts

Micronutrients		Wealthy areas (n = 330)		Less wealthy areas (n = 340)		p-value[2]
		Mean	95% CI	Mean	95% CI	
Vitamin A (mcg)	Total	754.0	718.0, 790.0	752.0	708.0, 796.0	0.925
	Boys	765.0	704.0, 826.0	761.0	711.0, 811.0	0.898
	Girls	743.0	693.0, 793.0	743.0	692.0, 793.0	0.989
Vitamin B1 (mg)	Total	1.4	1.3, 1.4	1.3	1.30, 1.39	0.003
	Boys	1.4	1.3, 1.5	1.3	1.32, 1.44	0.069
	Girls	1.3	1.3, 1.4	1.3	1.26, 1.36	0.017
Vitamin B2 (mg)	Total	1.6	1.61, 1.72	1.5	1.44, 1.59	0.000
	Boys	1.7	1.64, 1.80	1.5	1.47, 1.63	0.000
	Girls	1.6	1.54, 1.68	1.4	1.40, 1.56	0.015

Micronutrients		Wealthy areas (n = 330)		Less wealthy areas (n = 340)		p-value[2]
		Mean	95% CI	Mean	95% CI	
Vitamin B3 (mg)	Total	13.5	13.0, 14.1	12.8	12.48, 13.27	0.013
	Boys	13.9	13.4, 14.3	13.0	12.69, 13.37	0.023
	Girls	13.2	12.4, 14.1	12.7	12.12, 13.33	0.190
Vitamin C (mg)	Total	137.0	126.9, 147.5	130.4	122.8, 138.0	0.154
	Boys	138.0	124.3, 152.8	136.7	124.9, 148.5	0.790
	Girls	135.0	122.5, 149.1	124.1	116.9, 131.3	0.076
Calcium (mg)	Total	987.0	942.0, 1031.0	857.0	805.0, 909.0	0.000
	Boys	1016.0	970.0, 1061.0	895.0	826.0, 963.0	0.000
	Girls	958.1	900.0, 1015.0	819.0	781.0, 858.0	0.000
Magnesium (mg)	Total	190.0	182.0, 199.0	173.0	166.0, 180.0	0.000
	Boys	197.0	184.0, 209.0	173.0	166.0, 179.0	0.000
	Girls	184.0	174.0, 193.0	173.0	163.0, 182.0	0.071
Phosphorus (mg)	Total	1045.0	1012.0, 1077.0	973.0	930.0, 1016.0	0.000
	Boys	1078.0	1032.0, 1123.0	995.0	940.0, 1050.0	0.005
	Girls	1012.0	966.0, 1059.0	952.0	914.0, 990.0	0.048
Fe (mg)	Total	14.1	13.2, 14.9	13.5	13.0, 13.9	0.082
	Boys	14.5	13.2, 15.8	13.7	13.0, 14.3	0.079
	Girls	13.7	12.7, 14.6	13.3	12.8, 13.8	0.474
Zn[1]	Total	2.06	2.00, 2.13	2.00	1.93, 2.07	0.059
	Boys	2.11	2.03, 2.18	2.00	1.94, 2.06	0.017
	Girls	2.0	1.94, 2.11	2.01	1.92, 2.10	0.740

[1] *Transformed to the natural logarithm*
[2] *p-value was calculated from Student's t-test*

The energy intake and macronutrient intake of children aged four to five years by the household wealth index are shown in Table 7-5. Total energy intake across the three groups of wealth index was not significantly different. However, for boys, a greater intake of protein, especially animal protein, was found in those from the wealthiest families compared with their peers from the poorest households (p=0.006). Such a relationship was not seen for protein intake in children of both genders combined or in girls. Children from the wealthiest families appear to consume more animal fat than those from the poorest households, with the p-value close to a significant level (p=0.06), although the total fat intake (including animal and vegetable fat) was not significantly different between the groups. This difference came mainly from a significantly higher intake of animal fat in boys rather than girls, from the wealthiest families (p=0.008). There was no statistical difference in carbohydrate and fibre intake by the household wealth index.

Table 7-5 Mean intake of macronutrients by gender and the household wealth index
Means and 95% confidence interval for macronutrients in children aged 4 to 5 years by gender and the household wealth index

Nutrients		Poorest (n = 225)		Medium (n = 222)		Wealthiest (n = 223)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	
Energy (kcal)	Total	1592.0	1541.0, 1642.0	1598.0	1555.0, 1642.0	1617.0	1578.0, 1657.0	0.555
	Boys	1583.0	1509.0, 1657.0	1677.0	1590.0, 1763.0	1681.0	1622.0, 1740.0	0.106
	Girls	1601.0	1540.0, 1662.0	1534.0	1484.0, 1584.0	1543.0	1492.0, 1594.0	0.532
Protein (g)	Total	72.5	70.4, 74.6	76.3	72.6, 80.1	76.1	74.3, 77.9	0.070
	Boys	71.4	68.2, 74.5	70.5	67.6, 73.4	79.3	77.1, 81.6	0.006[1]
	Girls	73.6	70.0, 77.3	73.1	71.0, 75.3	72.3	69.9, 74.7	0.308
Animal protein (g)	Total	25.9	24.8, 27.0	47.2	45.4, 49.0	50.1	48.7, 51.5	0.008[1]
	Boys	25.7	24.2, 27.3	48.9	46.1, 51.7	52.6	50.9, 54.2	0.000[1]
	Girls	51.3	48.0, 54.5	45.8	43.4, 48.3	51.2	49.1, 53.3	0.270
Vegetable protein (g)	Total	28.1	26.9, 29.3	25.7	24.9, 26.4	25.8	24.8, 26.8	0.931
	Boys	27.9	26.2, 29.6	27.2	25.9, 28.5	26.6	25.2, 27.9	0.405
	Girls	26.1	24.9, 27.3	24.4	23.5, 25.3	24.9	23.6, 26.2	0.633
Fat (g)	Total	37.8	36.3, 39.2	38.5	36.6, 40.4	38.8	37.5, 40.0	0.581
	Boys	37.4	34.9, 39.8	39.8	36.6, 43.0	40.6	38.9, 42.4	0.099
	Girls	38.2	36.0, 40.3	37.5	35.6, 39.4	36.6	35.0, 38.3	0.786
Animal fat (g)	Total	25.4	24.3, 26.4	26.5	24.9, 28.2	27.3	26.1, 28.5	0.060
	Boys	25.2	23.7, 26.8	27.0	24.5, 29.5	28.7	27.5, 30.0	0.008[1]
	Girls	25.5	23.7, 27.3	26.1	24.5, 27.8	25.6	24.1, 27.1	0.966
Vegetable fat (g)	Total	12.2	11.5, 12.9	11.8	11.2, 12.4	11.3	10.8, 11.9	0.279
	Boys	12.0	10.9, 13.0	12.6	11.4, 13.7	11.8	10.8, 12.7	0.454
	Girls	12.4	11.5, 13.3	11.2	10.3, 12.1	10.9	10.2, 11.5	0.223
Carbohydrate (g)	Total	240.0	229.0, 252.0	240.0	234.0, 246.0	241.0	234.0, 249.0	0.803
	Boys	241.0	232.0, 250.0	254.0	241.0, 266.0	250.0	240.0, 260.0	0.248
	Girls	241.0	232.0, 249.0	229.0	222.0, 235.0	231.0	221.0, 241.0	0.687
Fibre (g)	Total	6.3	6.1, 6.6	6.3	6.1, 6.6	6.8	6.4, 7.1	0.106
	Boys	6.4	5.9, 6.8	6.8	6.2, 7.3	6.9	6.3, 7.4	0.365
	Girls	6.3	5.9, 6.7	6.0	5.5, 6.4	6.6	6.2, 7.1	0.144

[1] Means are significantly different between poorest and wealthiest groups, with ANOVA Bonferroni procedure

Table 7-6 presents a description of selected micronutrient intake in children aged four to five years by household wealth index. Children from the wealthiest households were shown to have greater intake of vitamin B1, calcium, phosphorus and zinc than those from the poorest households. A gender difference was found, where higher consumptions of these nutrients by boys rather than girls in the wealthiest families, contributed to the intake differences between children from wealthy and less wealthy households, except for zinc intake. Girls from the wealthiest families had higher zinc intake than those from the poorest families (p=0.0327) but this relationship was not seen for boys.

Table 7-6 Mean intake of selected micronutrients by household wealth index

Means and 95% confidence intervals for selected micronutrients in children aged 4 to 5 years by the household wealth index

Micronutrients		Poorest (n = 225)		Medium (n = 222)		Wealthiest (n = 223)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	
Vitamin A (mcg)	Total	734.0	695.0, 773.0	765.0	721.0, 810.0	759.0	717.0, 801.0	0.180
	Boys	722.0	652.0, 791.0	780.0	713.0, 847.0	786.0	733.0, 839.0	0.081
	Girls	746.0	688.0, 804.0	753.0	686.0, 820.0	728.0	671.0, 784.0	0.819
Vitamin B1 (mg)	Total	1.4	1.33, 1.41	1.3	1.3, 1.4	1.4	1.3, 1.44	0.196
	Boys	1.4	1.30, 1.43	1.4	1.3, 1.4	1.4	1.3, 1.50	0.224
	Girls	1.4	1.31, 1.43	1.3	1.2, 1.4	1.3	1.2, 1.41	0.482
Vitamin B2 (mg)	Total	1.5	1.45, 1.54	1.5	1.4, 1.6	1.6	1.5, 1.71	0.001[2]
	Boys	1.5	1.39, 1.60	1.6	1.4, 1.7	1.7	1.6, 1.78	0.003
	Girls	1.5	1.38, 1.61	1.5	1.4, 1.6	1.5	1.4, 1.64	0.899
Vitamin B3 (mg)	Total	13.0	12.6, 13.3	13.0	12.6, 13.4	13.3	12.9, 13.75	0.423
	Boys	12.7	12.2, 13.2	13.4	12.8, 14.0	13.7	13.2, 14.31	0.082
	Girls	13.2	12.5, 13.9	12.0	11.9, 13.4	12.8	12.2, 13.33	0.589
Vitamin C (mg)	Total	129.0	123.4, 135.0	128.0	121.0, 135.0	140.0	131.0, 150.0	0.117
	Boys	133.0	120.0, 147.0	135.0	124.0, 147.0	142.0	129.0, 155.0	0.757
	Girls	124.0	113.0, 135.0	122.0	113.0, 131.0	139.0	128.0, 150.0	0.089
Calcium (mg)	Total	849.0	816.0, 881.0	901.0	861.0, 941.0	958.0	912.0, 1003.0	0.001[2]
	Boys	857.0	798.0, 916.0	956.0	890.0, 1022.0	997.0	939.0, 1055.0	0.001
	Girls	840.0	796.0, 885.0	856.0	809.0, 903.0	911.0	859.0, 963.0	0.067
Magnesium (mg)	Total	179.0	172.0, 186.0	175.0	168.0, 183.0	182.0	173.0, 191.0	0.605
	Boys	177.0	165.0, 188.0	182.0	171.0, 193.0	185.0	174.0, 195.0	0.644
	Girls	181.0	168.0, 193.0	170.0	161.0, 179.0	179.0	169.0, 190.0	0.216
Phosphorus (mg)	Total	970.0	937.0, 1003.0	982.0	946.0, 1019.0	1043.0	1013.0, 1073.0	0.014[2]
	Boys	956.0	903.0, 1010.0	1023.0	965.0, 1081.0	1089.0	1050.0, 1128.0	0.002[2]
	Girls	984.0	927.0, 1041.0	949.0	906.0, 992.0	989.0	942.0, 1036.0	0.231
Fe (mg)	Total	13.7	13.1, 14.2	13.4	13.0, 13.9	14.0	13.5, 14.6	0.593
	Boys	13.4	12.4, 14.3	14.1	13.2, 14.9	14.4	13.6, 15.2	0.376
	Girls	13.9	13.1, 14.8	12.9	12.3, 13.5	13.6	13.1, 14.2	0.248
Zn[1]	Total	2.07	2.00, 2.14	1.96	1.89, 2.02	2.04	1.99, 2.09	0.024
	Boys	2.03	1.93, 2.13	1.99	1.90, 2.08	2.07	2.01, 2.14	0.383
	Girls	2.11	2.02, 2.19	1.93	1.85, 2.00	2.01	1.94, 2.08	0.033

[1] Transformed to the natural logarithm

[2] Means are significantly different between lowest and highest tertiles, with ANOVA Bonferoni procedure

Table 7-7 presents the mean intake of total energy and macronutrients for children aged four to five years according to paternal education levels. There were no significant differences in energy intake and macronutrient intake for children across the different paternal education levels, except for vegetable fat intake. The mean rank of vegetable fat intake for children across paternal education levels was statistically significantly different (p=0.0002) and the difference in vegetable fat intake was observed in girls (p=0.0015) but not boys.

Table 7-7 Mean energy intake and macronutrient intake by paternal education level

Means and 95% confidence interval of energy intake and macronutrient intakes in children aged 4 to 5 years by parental education levels

Nutrients		Primary school (n = 49)		Secondary school (n = 178)		High school (n = 272)		University/College (n = 167)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Energy (kcal)	Total	1577.0	1448.0, 1705.0	1634.0	1542.0, 1725.0	1612.0	1572.0, 1652.0	1558.0	1488.0, 1628.0	0.474
	Boys	1502.0	1331.0, 1673.0	1673.0	1576.0, 1771.0	1675.0	1607.0, 1744.0	1598.0	1482.0, 1714.0	0.261
	Girls	1621.0	1472.0, 1771.0	1588.0	1479.0, 1697.0	1552.0	1492.0, 1612.0	1515.0	1433.0, 1596.0	0.631
Protein (g)	Total	71.8	65.6, 78.1	74.7	70.5, 78.9	74.0	72.2, 75.9	73.4	70.1, 76.7	0.952
	Boys	68.0	62.7, 73.4	75.6	71.7, 79.6	76.8	74.1, 79.4	75.9	70.6, 81.2	0.368
	Girls	74.1	65.9, 82.3	73.7	67.8, 79.6	71.5	68.7, 74.3	70.7	66.2, 75.2	0.896
Animal protein (g)	Total	45.4	40.9, 49.9	47.8	45.0, 50.7	48.1	46.5, 49.6	48.3	45.8, 50.9	0.733
	Boys	43.0	40.1, 46.0	47.8	45.6, 50.1	50.0	48.1, 51.9	50.1	46.3, 54.0	0.137
	Girls	46.8	40.3, 53.3	47.9	43.1, 52.7	46.2	43.9, 48.5	46.4	42.8, 50.1	0.823
Vegetable protein (g)	Total	26.1	23.9, 28.4	26.6	24.9, 28.2	25.7	24.9, 26.6	24.8	23.7, 26.0	0.187
	Boys	24.7	21.9, 27.5	27.5	25.4, 29.6	26.6	25.3, 27.8	25.5	23.7, 27.3	0.291
	Girls	27.0	24.1, 29.9	25.5	24.1, 27.0	25.0	23.5, 26.4	24.1	22.7, 25.6	0.194
Fat (g)	Total	37.7	34.3, 41.1	39.1	35.7, 42.4	38.9	37.8, 40.0	36.8	34.7, 38.8	0.278
	Boys	35.3	30.3, 40.3	39.0	36.1, 41.8	40.6	38.5, 42.8	38.2	35.1, 41.4	0.278
	Girls	39.1	35.1, 43.1	39.2	34.3, 44.0	37.3	36.1, 38.5	35.2	32.6, 37.8	0.270
Animal fat (g)	Total	24.9	22.2, 27.7	26.3	23.8, 28.7	26.9	25.8, 28.0	26.1	24.4, 27.7	0.580
	Boys	24.0	19.6, 28.4	26.0	24.2, 27.8	28.2	26.6, 29.9	27.0	24.7, 29.3	0.106
	Girls	25.5	22.7, 28.3	26.6	22.9, 30.3	25.7	24.7, 26.7	25.2	22.9, 27.4	0.796
Vegetable fat (g)	Total	12.5	11.4, 13.7	12.6	11.5, 13.7	11.8	11.2, 12.4	10.5	9.9, 11.2	0.000[1]
	Boys	11.1	9.9, 12.3	12.8	11.6, 14.1	12.2	11.3, 13.2	11.1	10.0, 12.2	0.105
	Girls	13.4	11.5, 15.3	12.3	11.0, 13.7	11.4	10.4, 12.4	9.9	9.2, 10.6	0.001[1]
Carbohydrate (g)	Total	238.0	218.0, 257.0	246.0	233.0, 258.0	242.0	234.0, 249.0	234.0	222.0, 245.0	0.448
	Boys	228.0	201.0, 255.0	255.0	240.0, 270.0	251.0	240.0, 262.0	258.0	238.0, 278.0	0.195
	Girls	243.0	220.0, 266.0	235.0	223.0, 247.0	233.0	222.0, 244.0	229.0	217.0, 241.0	0.585
Fibre (g)	Total	6.3	5.6, 6.9	6.4	5.9, 6.9	6.4	6.2, 6.7	6.6	6.2, 7.2	0.595
	Boys	6.2	4.7, 7.6	6.8	6.1, 7.4	6.6	6.1, 7.1	6.7	6.0, 7.5	0.807
	Girls	6.3	5.4, 7.2	6.0	5.5, 6.5	6.3	5.9, 6.7	6.6	6.0, 7.1	0.426

[1] *p-value was obtained from Kruskal-Wallis method*

The mean intake of micronutrients in children aged four to five years according to paternal education levels are shown in Table 7-8. Only calcium intake was found to be statistically different across paternal education levels. Children, whose fathers attained a college or university degree, had a greater intake of calcium than those whose fathers attained primary and secondary schools (p=0.04, 0.02 respectively). Girls were shown to have a greater intake of calcium, but calcium intake by boys was not significantly different across different paternal education levels. Girls whose fathers finished college or university level were shown to consume more calcium than those whose parents finished primary and secondary school.

Table 7-8 Mean intake of selected micronutrients by paternal education level

Means and 95% confidence interval for energy intake and macronutrient intakes in children aged 4 to 5 years by parental education levels

Nutrients		Primary school (n = 49)		Secondary school (n = 178)		High school (n = 272)		University/College (n = 167)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Vitamin A (mcg)	Total	758.0	683.0, 832.0	767.0	689.0, 845.0	740.0	695.0, 785.0	757.0	726.0, 787.0	0.692
	Boys	802.0	686.0, 918.0	766.0	689.0, 843.0	739.0	686.0, 793.0	784.0	726.0, 843.0	0.365
	Girls	731.7	608.0, 855.0	768.0	654.0, 882.0	741.0	681.0, 799.0	727.0	676.0, 778.0	0.995
Vitamin B1 (mg)	Total	1.3	1.2, 1.5	1.3	1.2, 1.4	1.3	1.3, 1.4	1.3	1.3, 1.4	0.975
	Boys	1.3	1.2, 1.4	1.4	1.3, 1.4	1.4	1.3, 1.4	1.3	1.2, 1.5	0.816
	Girls	1.4	1.2, 1.5	1.3	1.2, 1.4	1.3	1.2, 1.3	1.3	1.2, 1.4	0.967
Vitamin B2 (mg)	Total	1.4	1.3, 1.57	1.5	1.4, 1.6	1.5	1.5, 1.6	1.6	1.5, 1.7	0.153
	Boys	1.4	1.2, 1.69	1.5	1.4, 1.6	1.6	1.5, 1.6	1.6	1.5, 1.8	0.398
	Girls	1.4	1.2, 1.59	1.5	1.3, 1.6	1.5	1.4, 1.5	1.5	1.4, 1.7	0.577
Vitamin B3 (mg)	Total	12.9	12.1, 13.74	13.3	12.6, 14.0	13.0	12.4, 13.6	13.1	12.5, 13.6	0.935
	Boys	12.1	11.8, 12.57	13.4	12.7, 14.1	13.3	12.7, 13.9	13.4	12.6, 14.2	0.534
	Girls	13.4	12.0, 14.72	13.1	12.1, 14.2	12.7	12.0, 13.4	12.7	11.9, 13.5	0.988
Vitamin C (mg)	Total	123.0	105.0, 142.0	130.0	120.0, 139.0	130.0	122.0, 137.0	143.0	131.0, 154.0	0.187
	Boys	131.0	77.0, 184.0	139.0	123.0, 155.0	133.0	122.0, 145.0	142.0	124.0, 160.0	0.741
	Girls	119.0	100.0, 137.0	119.0	107.0, 132.0	127.0	117.0, 136.0	143.0	130.0, 155.0	0.092
Calcium (mg)	Total	801.0	701.0, 900.0	857.0	805.0, 909.0	914.0	877.0, 950.0	967.0	918.0, 1017.0	0.004[1], 0.002[2]
	Boys	826.0	644.0, 1008.0	888.0	829.0, 947.0	954.0	907.0, 1001.0	993.0	916.0, 1069.0	0.091
	Girls	785.0	682.0, 889.0	822.0	732.0, 911.0	876.0	830.0, 923.0	940.0	863.0, 1017.0	0.038[1], 0.024[2]
Magnesium (mg)	Total	180.0	164.0, 195.0	177.0	167.0, 188.0	177.0	171.0, 183.0	183.0	172.0, 194.0	0.613
	Boys	179.0	157.0, 202.0	181.0	168.0, 193.0	180.	174.0, 187.0	184.0	168.0, 200.0	0.965
	Girls	180.0	158.0, 202.0	174.0	160.0, 187.0	174.0	164.0, 183.0	182.0	166.0, 198.	0.556
Phosphorus (mg)	Total	954.0	864.0, 1043.0	990.0	932.0, 1048.0	1009.0	980.0, 1038.0	1004.0	959.0, 1049.0	0.884
	Boys	923.0	780.0, 1066.0	999.0	949.0, 1048.0	1048.0	1007.0, 1089.0	1037.0	954.0, 1120.0	0.444
	Girls	972.0	875.0, 1069.0	980.0	889.0, 1070.0	972.0	935.0, 1009.0	969.0	909.0, 1030.0	0.978
Fe (mg)	Total	13.9	12.7, 15.2	14.1	13.1, 14.9	13.5	13.0, 13.9	13.6	12.8, 14.5	0.890
	Boys	13.6	11.7, 15.5	14.4	13.2, 15.5	13.7	13.0, 14.4	14.0	12.6, 15.3	0.808
	Girls	14.2	12.5, 15.9	13.7	12.6, 14.8	13.3	12.6, 13.9	13.3	12.2, 14.3	0.659
Zn[3]	Total	2.09	1.97, 2.21	2.08	2.01, 2.14	2.01	1.93, 2.08	1.9	1.8, 2.0	0.069
	Boys	2.01	1.89, 2.13	2.09	2.02, 2.15	2.03	1.97, 2.09	1.9	1.8, 2.0	0.180
	Girls	2.14	1.96, 2.31	2.07	1.96, 2.17	1.98	1.87, 2.09	1.9	1.8, 2.0	0.313

[1] Mean intakes were statistically significantly different between primary vs college/university levels, with ANOVA Bonferoni procedure

[2] Mean intakes were statistically significantly different between secondary vs college/university levels, with ANOVA Bonferoni test procedure

[3] Transformed to the natural logarithm

Table 7-9 describes of energy intake and macronutrient intake for children aged four to five years according to maternal education level. Children, whose mothers attained a college or university education, had greater total energy, vegetable protein and carbohydrate intake than those whose mothers had completed primary or secondary schools (p=0.031, 0.003, 0.0001, 0.0062 respectively). There were consistent gender differences in energy, vegetable protein, and carbohydrate intake across maternal education levels, but not for vegetable fat. Boys, whose mothers had completed college or university, were seen to have a significantly higher energy, vegetable protein and carbohydrate intake than those whose mothers completed primary school (p=0.009, 0.0024, 0.0033 respectively). These relationships were not found in girls. The mean ranks of vegetable fat across maternal education levels were statistically significantly different (p=0.0001) and children of both genders, whose mothers finished college and university, had a higher vegetable fat intake than those whose mothers finished primary school (p=0.0005 for boys and p=0.019 for girls).

Table 7-9 Mean energy intake and macronutrient intake by maternal education level

Means and 95% confidence intervals of energy intake and macronutrient intakes in children aged 4 to 5 years according to maternal education levels

Nutrients		Primary school (n = 66)		Secondary school (n = 227)		High school (n = 257)		University/College (n = 118)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Energy (kcal)	Total	1544.0	1457.0, 1631.0	1570.0	1486.0, 1653.0	1583.0	1535.0,1631.0	1660.0	1599.0, 1722.0	0.031[1]
	Boys	1525.0	1378.0, 1671.0	1562.0	1462.0, 1662.0	1656.0	1579.0, 1734.0	1713.0	1631.0, 1795.0	0.009[1]
	Girls	1565.0	1486.0, 1644.0	1576.0	1452.0, 1701.0	1516.0	1476.0, 1556.0	1603.0	1525.0, 1682.0	0.699
Protein (g)	Total	71.9	67.6, 76.1	71.2	67.7, 74.6	73.6	71.6, 75.7	75.9	73.3, 78.5	0.108
	Boys	71.7	65.3, 78.2	70.1	64.8, 75.4	77.3	74.0, 80.6	77.3	74.4, 80.3	0.052
	Girls	72.0	68.3, 75.7	72.0	66.2, 77.9	70.3	68.4, 72.1	74.4	70.1, 78.7	0.573
Animal protein (g)	Total	47.3	44.2, 50.5	45.2	42.4, 48.1	48.1	46.8, 49.6	27.1	25.7, 28.5	0.290
	Boys	47.7	43.2, 52.2	44.1	39.4, 48.8	50.8	48.5, 53.0	28.0	26.1, 29.9	0.080
	Girls	47.0	43.9, 50.0	46.2	41.7, 50.7	45.8	44.2, 47.3	48.0	44.6, 51.3	0.543
Vegetable protein (g)	Total	24.3	22.7, 26.0	25.6	23.9, 27.3	25.3	24.5, 26.1	29.3	27.8, 30.9	0.003[1]
	Boys	23.8	21.6, 26.1	25.7	23.8, 27.6	26.4	24.9, 27.8	30.3	28.3, 32.4	0.002[1]
	Girls	24.9	22.7, 27.1	25.5	23.3, 27.8	24.3	23.5, 25.1	26.1	24.4, 27.7	0.587
Fat (g)	Total	36.7	33.6, 39.7	37.6	35.5, 39.6	38.4	36.9, 40.0	39.3	37.5, 41.0	0.202
	Boys	36.4	31.9, 41.0	37.0	34.1, 39.8	40.2	37.9, 42.5	40.3	38.0, 42.5	0.074
	Girls	36.9	34.4, 39.4	38.1	35.1, 41.0	36.9	35.4, 38.4	38.2	35.8, 40.7	0.681
Animal fat (g)	Total	26.3	24.0, 28.7	25.3	23.5, 27.1	26.9	25.7, 28.1	26.2	24.9, 27.5	0.632
	Boys	26.2	22.8, 29.5	24.9	22.7, 27.1	28.2	26.6, 29.8	26.8	25.4, 28.2	0.156
	Girls	26.5	24.3, 28.7	25.6	22.8, 28.4	25.8	24.6, 27.0	25.5	23.6, 27.4	0.805
Vegetable fat (g)	Total	10.2	9.2, 11.2	12.1	11.2, 12.9	11.4	10.8, 11.9	12.9	12.0, 13.8	0.000[2]
	Boys	10.2	8.6, 11.7	11.8	10.5, 13.2	11.8	10.7, 13.0	13.2	11.9, 14.6	0.000[1]
	Girls	10.3	9.0, 11.6	12.2	10.6, 13.8	10.9	10.3, 11.5	12.5	11.3, 13.8	0.019[1]
Carbohydrate (g)	Total	232.0	219.0, 245.0	237.1	221.9, 252.3	236.3	228.0, 244.0	251.0	240.0, 262.0	0.006[1]
	Boys	228.0	206.0, 249.0	237.4	221.8, 253.0	247.2	234.0, 260.0	260.0	247.0, 274.0	0.003[1]
	Girls	237.0	222.0, 251.0	236.9	215.4, 258.3	226.5	219.0, 233.0	240.0	228.0, 252.0	0.556
Fibre (g)	Total	6.3	5.6, 7.0	6.0	5.5, 6.4	6.4	6.2, 6.7	6.7	6.4, 7.1	0.595
	Boys	6.2	5.5, 6.9	6.1	5.3, 6.9	6.7	6.0, 7.3	7.0	6.5, 7.5	0.074
	Girls	6.4	5.5, 7.4	5.9	5.4, 6.4	6.2	5.9, 6.6	6.4	5.9, 7.0	0.611

[1] Means are significantly different between primary school level vs college/university level, with ANOVA Bonferoni procedure

[2] p-value was obtained from Kruskal-Wallis test

Table 7-10 presents the mean intake of selected micronutrients by maternal education levels. As can be seen from this table, greater intake of calcium and zinc was seen in those whose mothers attained college or university level education. Children, whose mothers finished primary school, consumed less calcium than those whose mothers finished high school or higher levels of education (p=0.01, 0.001 respectively). Gender-specific analyses showed that the difference in calcium intake across maternal education levels was from girls rather than from boys (p=0.033, 0.0033 respectively). Similar patterns were found for zinc intake. Higher zinc intake was observed in children whose mothers attained a high school or higher level of education compared with those whose mothers had a primary school education (p=0.001, 0.034 respectively). However, the difference in zinc intake across maternal education levels was greater in boys than in girls (p=0.021, 0.001). Iron intake was also found to relate to maternal education level with mean ranks of iron intake across maternal education levels being significantly different (p=0.040). Maternal education levels appear to have no impact on vitamin A and B, magnesium and phosphorus intake.

Table 7-10 Mean intake of selected micronutrients by maternal education level

Means and 95% confidence intervals for selected micronutrients in children aged 4 to 5 years according to maternal education levels

Nutrients		Primary school (n = 66)		Secondary school (n = 227)		High school (n = 257)		University/College (n = 118)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Vitamin A (mcg)	Total	712.0	652.0, 772.0	746.0	671.0, 821.0	736.0	703.0, 769.0	793.0	741.0, 844.0	0.131
	Boys	724.0	633.0, 814.0	726.0	606.0, 847.0	756.0	709.0, 802.0	795.0	746.0, 845.0	0.534
	Girls	700.0	640.0, 758.0	762.0	676.0, 848.0	718.0	679.0, 757.0	790.0	711.0, 868.0	0.792
Vitamin B1 (mg)	Total	1.3	1.2, 1.4	1.3	1.2, 1.4	1.38	1.3, 1.4	1.4	1.3, 1.4	0.685
	Boys	1.3	1.1, 1.4	1.3	1.2, 1.4	1.43	1.3, 1.5	1.4	1.3, 1.5	0.242
	Girls	1.3	1.2, 1.4	1.3	1.2, 1.4	1.34	1.2, 1.3	1.3	1.2, 1.4	0.894
Vitamin B2 (mg)	Total	1.6	1.4, 1.7	1.4	1.3, 1.5	1.58	1.5, 1.6	1.5	1.5, 1.6	0.082
	Boys	1.6	1.4, 1.7	1.4	1.3, 1.5	1.62	1.5, 1.6	1.6	1.5, 1.6	0.283
	Girls	1.5	1.4, 1.7	1.4	1.3, 1.5	1.53	1.4, 1.5	1.5	1.4, 1.6	0.370
Vitamin B3 (mg)	Total	12.5	11.8, 13.2	12.7	12.1, 13.4	12.97	12.5, 13.4	13.6	13.1, 14.2	0.074
	Boys	12.4	11.4, 13.4	12.3	11.3, 13.3	13.54	12.7, 14.2	13.7	13.2, 14.3	0.072
	Girls	12.6	11.88, 13.3	13.1	11.8, 14.4	12.46	11.9, 12.9	13.5	12.6, 14.4	0.368
Vitamin C (mg)	Total	135.0	119.0, 150.0	125.0	112.0, 138.0	132.6	124., 140.0	134.0	125.0, 142.0	0.407
	Boys	132.0	115.0, 150.0	130.0	103.0, 156.0	136.8	122.0, 150.0	141.0	130.0, 152.0	0.762
	Girls	137.0	118.0, 156.0	121.0	107.0, 134.0	128.8	119.0, 138.0	125.0	113.0, 138.0	0.275

Table 7-11 Mean intake of selected micronutrients by maternal education level

Nutrients		Primary school (n = 66)		Secondary school (n = 227)		High school (n = 257)		University/College (n = 118)		p-value
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Calcium (mg)	Total	798.0	743.0, 853.0	887.0	834.0, 940.0	916.0	881.0, 952.0	966.0	911.0, 1021.0	0.01[1], 0.001[2]
	Boys	848.0	795.0, 902.0	941.0	868.0, 1014.0	935.0	883.0, 987.0	979.0	913.0, 1045.0	0.4200
	Girls	756.0	678.0, 835.0	827.0	777.0, 878.0	899.0	858.0, 940.0	952.0	878.0, 1026.0	0.003[1], 0.033[2]
Magnesium (mg)	Total	174.0	161.0, 187.0	171.0	159.0, 183.0	176.0	170.0, 183.0	186.0	178.0, 193.0	0.1300
	Boys	173.0	156.0, 190.0	171.0	154.0, 188.0	179.0	168.0, 190.0	189.0	181.0, 198.0	0.3350
	Girls	176.0	163.0, 189.0	171.0	154.0, 187.0	174.0	167.0, 181.0	181.0	169.0, 194.0	0.8041
Phosphorus (mg)	Total	1006.0	941.0, 1071.0	950.0	895.0, 1005.0	1001.0	970.0, 1032.0	1007.0	967.0, 1046.0	0.6630
	Boys	1001.0	902.0, 1101.0	949.0	867.0, 1030.0	1043.0	999.0, 1087.0	1033.0	991.0, 1076.0	0.3990
	Girls	1011.0	952.0, 1070.0	952.0	876.0, 1028.0	961.0	929.0, 993.0	977.0	917.0, 1038.0	0.5960
Fe (mg)	Total	13.0	11.8, 14.2	13.6	12.6, 14.5	13.4	13.0, 13.8	14.4	13.71, 15.0	0.04044[3]
	Boys	12.9	11.3, 14.46	13.5	11.9, 15.2	13.8	13.0, 14.6	14.7	13.9, 15.4	0.0850
	Girls	13.1	12.0, 14.2	13.6	12.4, 14.8	13.1	12.7, 13.5	14.1	13.1, 15.1	0.7742
Zn[4]	Total	1.9	1.8, 1.9	1.99	1.94, 2.05	2.1	2.0, 2.2	2.1	2.0, 2.1	0.022[1], 0.001[2]
	Boys	1.8	1.7, 1.9	2.07	1.88, 2.26	2.0	1.9, 2.1	2.1	2.0, 2.1	0.0013[2]
	Girls	1.9	1.8, 2.0	1.98	1.90, 2.05	2.1	1.9, 2.3	2.0	1.9, 2.1	0.2310

[1] *Means are significantly different between primary school vs high school levels, with ANOVA Bonferoni procedure*
[2] *Means are significantly different between primary school vs college/university levels, with ANOVA Bonferoni procedure*
[3] *p-value was calculated from Kruskal-Wallis test*
[4] *Transformed to the natural logarithm*

Table 7-11 shows the percentage of children aged four to five years who had a percentage of energy from macronutrients that met or exceeded the 2007 RDA for children of both genders at this age, and who had an adequate micronutrient intake. More than one half of the children consumed a total caloric intake greater than the recommendation (58.3%). There were more boys with total energy intake exceeding the recommended level than girls (p=0.037). There was no child with mean energy intake from protein, expressed as a percentage of energy from protein, less than 12% (RDA: 12-15%). There were only 1.9% of children who met the recommendation while the other 98.1% exceeded the recommendation for energy intake from protein.

Compared with protein intake, there was a higher proportion of children (73%) with mean energy intake from fat meeting the recommendation (RDA: 18-25%) while the other 12.7% exceeded the recommended level for energy intake from fat. In all children, the energy contribution from animal fat was greater than the recommended 30% of total energy intake from fat. The dietary intake of 52.9% of the children met the recommended percentage of energy from carbohydrates and only 0.6% exceeded the recommended range. Thus, nearly half the children consumed less carbohydrate than recommended.

A much higher percentage of children, ranging from 95% to 100%, were observed to have an adequate dietary intake of micronutrients. There were no gender differences found in the proportion of children with adequate mean energy intake from macronutrients and adequate micronutrient intake, except for calcium intake. The proportion of children with adequate intake of calcium was significantly higher for girls than for boys (98% and 95% respectively, p=0.048).

Table 7-12 Percent of energy from macronutrients meeting or exceeding the 2007 RDA[1] and with adequacy[2] of nutrient intake

Percentage and 95% confidence interval of children aged 4 to 5 years with percent of energy from macronutrients meeting or, exceeding the 2007 RDA and with adequate nutrient intake by gender

Energy intake and nutrients	Total (n = 670)		Boys (n = 333)		Girls (n = 337)		p-value[3]
	%	95% CI	%	95% CI	%	95% CI	
Energy (kcal) meeting RDA	31.7	27.5, 36.3	29.3	24.7, 34.4	34.1	28.6, 40.1	0.186
Energy (kcal) exceeding RDA	58.3	54.6, 62.0	62.5	57.3, 67.5	54.2	49.4, 58.9	0.037
% energy from protein meeting RDA	1.9	0.9, 3.8	2.7	1.1, 6.6	1.0	0.4, 2.7	0.236
% energy from protein exceeding RDA	98.1	96.2, 99.1	97.3	93.4, 98.9	99.0	97.3, 99.6	0.236
% energy from fat meeting RDA	86.0	81.4, 89.7	85.2	80.2, 89.1	86.8	80.5, 91.4	0.594
% energy from fat exceeding RDA	12.7	8.9, 18.0	12.6	7.8, 19.8	12.9	8.2, 19.6	0.950
% energy from animal fat exceeding RDA	100.0	_	100.0	_	100.0	_	_
% energy from carbohydrate meeting RDA	52.9	46.7, 59.1	51.5	44.2, 58.7	54.3	45.2, 63.1	0.649
% energy from carbohydrate exceeding RDA	0.6	0.2, 2.3	0.8	0.1, 5.4	0.4	0.1, 1.6	0.990
Vitamin A adequacy (mcg)	95.5	92.2, 97.4	96.8	93.0, 98.6	94.2	89.8, 96.8	0.179
Vitamin B1 adequacy (mg)	100.0	_	100.0	_	100.0	_	
Vitamin B2 adequacy (mg)	100.0	_	100.0	_	100.0	_	
Vitamin B3 adequacy (mg)	99.5	97.6, 99.9	99.6	97.2, 99.9	99.4	97.5, 99.9	0.570
Vitamin C adequacy (mg)	99.8	98.6, 99.9	100.0	_	99.6	97.3, 99.9	0.320
Calcium adequacy (mg)	96.5	94.6, 97.7	98.0	96.0, 99.0	95.0	92.1, 96.8	0.049
Fe adequacy (mg)	98.6	97.1, 99.3	98.8	95.3, 99.7	98.3	95.5, 99.4	0.487
Zn[4] adequacy	97.9	96.7, 98.8	98.8	96.9, 99.6	97.1	94.5, 98.5	0.084

[1] Based on the 2007 RDA
[2] Based on total intake at or above 77% of the 2007 RDA cut off values
[3] p-value was calculated from Student's t-test
[4] Transformed to the natural logarithm

Table 7-12 shows the proportion of children from wealthy and less wealthy districts with the percentage of energy from macronutrients that met or exceeded the 2007 RDA for children and micronutrient adequacy, at this age. There was no difference in the proportion of children with mean energy intake from macronutrients meeting or exceeding the recommendation as well as adequacy of micronutrient intake, between both groups of districts, except for total and fat intake. There was a higher proportion of children from less wealthy districts, with mean energy intake from fat in the recommended range, than children from wealthy districts (p=0.030). In contrast, there were more children from wealthy districts who had the total energy intake exceeding the recommendation than those from less wealthy districts (p=0.003). With regard to fat intake, the proportion of children exceeding the recommended level for the percentage of energy intake from fat was significantly higher for those from less wealthy districts than those from wealthy districts (p=0.009). However, children from wealthy districts appeared to be more likely to meet the recommendation for vitamin A, calcium and iron intake than those from less wealthy districts (p=0.037, 0.054, and 0.036 respectively).

Table 7-13 Percent of energy from macronutrients meeting or exceeding the 2007 RDA[1] and the adequacy[2] of micronutrient intake by district

Percentage and 95% confidence intervals of children aged 4 to 5 years with percent of energy from macronutrients meeting or exceeding the 2007 RDA and with adequate micronutrient intakes by districts

Energy intake and nutrients	Total (n = 670)		Wealthy areas (n = 330)		Less wealthy areas (n = 340)		p-value[3]
	%	95% CI	%	95% CI	%	95% CI	
Energy (kcal) meeting RDA	31.7	27.5, 36.3	26.7	21.9, 31.9	34.4	28.0, 41.41	0.030
Energy (kcal) exceeding RDA	58.3	54.6, 62.0	65.8	61.0, 70.2	54.4	48.7, 60.0	0.003
% energy from protein meeting RDA	1.9	0.9, 3.8	2.7	1.1, 6.6	1.0	0.4, 2.7	0.596
% energy from protein exceeding RDA	98.1	96.2, 99.1	98.5	96.9, 99.3	97.9	94.3, 99.3	0.596
% energy from fat meeting RDA	86.0	81.4, 89.7	85.8	78.9, 90.6	86.2	79.0, 91.2	0.071
% energy from fat exceeding RDA	12.7	8.9, 18.0	8.5	6.1, 11.6	15.0	9.0, 23.9	0.009
% energy from animal fat exceeding RDA	100.0	_	100.0	_	100.0	_	_
% energy from carbohydrate meeting RDA	52.9	46.7, 59.1	45.5	38.6, 52.5	47.1	37.6, 56.7	0.681
% energy from carbohydrate exceeding RDA	0.6	0.2, 2.3	0.6	0.1, 2.5	0.6	0.01, 4.9	0.976
Vitamin A adequacy (mcg)	95.5	92.2, 97.4	96.8	93.0, 98.6	94.2	89.8, 96.8	0.037
Vitamin B1 adequacy (mg)	100.0	_	100.0	_	100.0	_	_
Vitamin B2 adequacy (mg)	100.0	_	100.0	_	100.0	_	_
Vitamin B3 adequacy (mg)	99.5	97.6, 99.9	99.7	97.5, 99.9	99.4	95.2, 99.9	0.580
Vitamin C adequacy (mg)	99.8	98.6, 99.9	98.2	95.4, 99.3	99.7	97.6, 99.9	0.324
Calcium adequacy (mg)	96.5	94.6, 97.7	98.0	95.4, 99.3	95.6	92.6, 97.4	0.054
Fe adequacy (mg)	98.6	97.1, 99.3	99.7	97.4, 99.9	97.9	95.5, 99.1	0.036
Zn[4] adequacy	97.9	96.7, 98.8	99.1	95.9, 99.8	97.4	95.4, 98.5	0.090

[1] Based on the 2007 RDA
[2] Based on total intake at or above 77% of the 2007 RDA cut off values
[3] p-value was calculated from Student's t-test
[4] Transformed to the natural logarithm

Table 7-13 presents the proportion of children with mean energy intake from macronutrients that met or exceeded the 2007 RDA for children at this age and with micronutrient adequacy by the household wealth index. The role of household wealth index appears to be less significant than the economic level of the community in terms of total caloric intake and energy contribution from macronutrients. There were no significant differences in the proportion of children with energy intake from protein, fat or carbohydrate within or exceeding the recommended ranges across the different groups of household economic status. For micronutrients, the percentage of children with adequate vitamin A and iron intake was highest in those from the wealthiest households (p=0.029, 0.030 respectively).

Table 7-14 Percent of energy from macronutrients meeting or exceeding the 2007 RDA[1] and the adequacy[2] of micronutrient intake by household wealth index

Percentage and 95% confidence interval of children aged 4 to 5 years with percent of energy from macronutrients meeting or exceeding the 2007 RDA and with adequate micro nutrient intakes by household wealth index

Energy intake and nutrients	Total (n = 670)		Poorest (n = 225)		Medium (n = 222)		Wealthiest (n = 340)		p-value[3]
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	
Energy (kcal) meeting RDA	31.7	27.5, 36.3	27.8	22.2, 34.3	32.9	27.6, 38.7	34.6	28.2, 41.5	0.544
Energy (kcal) exceeding RDA	58.3	54.6, 62.0	56.5	52.1, 60.9	57.6	52.3, 62.8	60.9	53.9, 67.4	0.436
% energy from protein meeting RDA	1.9	0.9, 3.8	2.6	1.0, 7.0	1.2	0.2, 7.7	1.8	0.7, 4.9	0.371
% energy from protein exceeding RDA	98.1	96.2, 99.1	97.4	93.0, 99.0	98.9	92.3, 99.8	97.9	94.3, 99.3	0.371
% energy from fat meeting RDA	86.0	81.4, 89.7	84.9	79.5, 89.0	86.1	79.7, 90.7	86.2	79.0, 91.2	0.383
% energy from fat exceeding RDA	12.7	8.9, 18.0	8.2	4.3, 15.0	14.3	8.6, 22.8	15.0	9.0, 23.9	0.107
% energy from animal fat exceeding RDA	100.0	_	100.0	_	100.0	_	100.0	_	_
% energy from carbohydrate meeting RDA	52.9	46.7, 59.1	56.6	48.7, 64.2	54.5	45.8, 62.9	47.4	39.8, 55.1	0.221
% energy from carbohydrate exceeding RDA	0.6	0.2, 2.3	0.9	0.2, 3.8	0.6	0.001, 4.1	0.3	0.0, 2.3	0.784
Vitamin A adequacy (mcg)	95.5	92.2, 97.4	96.8	93.0, 98.6	94.2	89.8, 96.8	94.2	89.8, 96.8	0.029
Vitamin B1 adequacy (mg)	100.0	_	100.0	_	100.0	_	100.0	_	
Vitamin B2 adequacy (mg)	100.0	_	100.0	_	100.0	_	100.0	_	
Vitamin B3 adequacy (mg)	99.5	97.6, 99.9	98.9	92.3, 99.8	99.7	97.8, 99.9	99.4	95.2, 99.9	0.363
Vitamin C adequacy (mg)	99.8	98.6, 99.9	99.4	96.3, 99.9	100.0	_	99.7	97.6, 99.9	0.371
Calcium adequacy (mg)	96.5	94.6, 97.7	95.7	92.4, 97.6	95.4	91.9, 97.4	95.6	92.6, 97.4	0.172
Fe adequacy (mg)	98.6	97.1, 99.3	96.9	92.2, 98.8	98.9	95.9, 99.7	97.9	95.5, 99.1	0.030
Zn[4] adequacy	97.9	96.7, 98.8	96.8	93.4, 98.5	97.7	94.8, 99.0	97.4	95.4, 98.5	0.105

[1] Based on the 2007 RDA
[2] Based on total intake at or above 77% of the 2007 RDA cut off values
[3] p-value was calculated from Student's t-test
[4] Transformed to the natural logarithm

7.4 Discussion

In this study, the dietary intake of children aged four to five years from urban areas of Ho Chi Minh City (HCMC) was measured by combining the responses to an FFQ administered to both the teacher and parents of the children. The diet of this child population contained more energy from protein and fat, and less energy from carbohydrate, than recommended. The micronutrient intake of these children was adequate. Such diet patterns appear to be more pronounced in children from higher socioeconomic class, such as a higher household wealth index, higher parental education levels, and location of residence in a wealthy area.

As noted in Chapters 4 and 5, the prevalence of overweight and obesity is increasing among preschool aged children in urban areas of HCMC. Therefore, the macronutrient intake of this population, especially the mean energy intake, is of great interest. While studies on dietary patterns in young children in developed countries have observed a slight decrease or stability in total energy intake in young children over past decades (Ronette and Clifford, 2004, Glynn et al., 2005), the findings in the present study have shown that more than half the children aged four to five years (58.3%) consumed total energy intake exceeding the recommendation for children at this age. However, there are no previous reports of dietary intake for comparison of the findings from this study and for assessing how dietary intake has changed recently.

There was an imbalance in the protein intake among children in the study, with higher than expected protein intake and a higher contribution of protein to energy intake than recommended. Almost all children (98.1%) had a diet with a percentage of energy intake from protein exceeding the recommended range of 12-15%. Mean energy intake from protein for children in this study was greater than that reported for English children aged seven years (13.0%) (Glynn et al., 2005) and Italian children aged five years (15%) (Verduci et al., 2007). It has been hypothesised that a high protein intake may trigger adipocyte multiplication by stimulating the production of an insulin-like hormone (Rolland-Cachera et al., 1995). High protein consumption in preschool children in this study indicates that this dietary factor needs careful evaluation as a candidate risk factor for longitudinal changes in adiposity (see Chapter 8).

Although mean intake from fat, expressed as a percentage of energy from fat, was in accordance with the recommendation, 13% of the children consumed energy from fat that exceeded the recommendation. Additionally, consumption of animal fat contributed 70% to the overall percentage of energy from fat, which was the opposite of the recommendation of 70% of energy from fat being from a vegetable source. The reported mean fat intake, as a percentage of energy from fat (21.4%), was much lower in children of a similar age in the United States with (31.2%) (Richard et al., 2000) and in Italy (35.3% for boys and 36.1% for girls) (Verduci et al., 2007). However, animal fat is the source of saturated fats that are associated with cardiovascular diseases in children and adults when high levels are consumed (Berenson et al., 1998, Catherine et al., 2004). These results imply an early exposure to a risk factor for the development of an important chronic disease later in life.

Nearly one half of the children (46.5%) had a contribution of carbohydrates to their total energy intake below the recommended levels. This finding suggests that energy from carbohydrate has been replaced by protein and fat intake. This pattern indicates a shift away from traditional Vietnamese dietary patterns, where rice (carbohydrate) was the main source of calories. Although dietary intake data for children at the specific ages examined in this study are not available at the national level, the findings of this study are consistent with the dietary changes of increasing fat and protein consumption in Vietnamese adults as reported in the national food survey in 2000. These dietary changes observed in the 2000 national food survey were greatest in urban populations that are undergoing rapid economic and social changes, such as in Ho Chi Minh city (Khoi and Khan, 2004).

Findings from studies on dietary patterns of children in developed countries, have noted a significant proportion of energy coming from non-milk extrinsic sugars or added sugar in total energy from carbohydrate (Kathryn et al., 1997, Glynn et al., 2005). This is of concern in terms of diet quality and source of calories, since the main sources were soft drinks and desserts and their influence on body weight of children has been documented (Sibylle et al., 2005). However, it was not possible to assess the contribution of added sugar consumption to total energy intake in this study. Similarly, food groups such as cereals, fruit and vegetables, dairy and meat could not be calculated from the FFQ data collected. Since the individual consumes foods and not nutrients, it has been suggested that dietary studies should examine the role of individual foods and food groups, to be better able to provide dietary advice (Newby, 2007). Despite this study's highlights, there remains a gap in our understanding of dietary intake patterns in young children in urban populations in Vietnam that requires further investigation.

In this study, gender differences in nutrient intake were observed, and boys rather than girls were shown to have greater intakes of most of nutrients , particularly total energy, protein and fat intake. This gender difference was consistent among wealthy and less wealthy districts as well as by household economic status. The findings were in agreement with studies of dietary intake of similarly aged children in developed countries (Glynn et al., 2005, Verduci et al., 2007). The gender differences in dietary intake patterns were seen to match with the significantly higher levels of obesity in boys, as reported in Chapters 4 and 5. It may be hypothesised that boys are preferred over girls and often better nourished than girls in Vietnam thus resulting in a gender difference in dietary patterns and overweight and obesity prevalence. However, further study is needed to clarify this hypothesis.

The socioeconomic status at the community and household levels appears to have an impact on food intake patterns in this child population. Children from wealthy districts, wealthiest families and those whose parents attained higher levels of education, had higher intakes of energy, protein, fat and carbohydrate and some micronutrients (vitamin group B, calcium and zinc), than their counterparts from less wealthy districts, poorer households and those whose parents had lower education levels. However, the proportion of children with a percentage of energy from macronutrients exceeding the recommendations was similar in wealthy and less wealthy districts, suggesting that changes in dietary intake patterns are occurring throughout the urban areas of HCMC. There was the difference in implication of socioeconomic status at household and community levels, on the food habits of children in developed countries compared with the findings in this study. Lower community and household socioeconomic status and lower parental education levels have been reported as being associated with unhealthy diets of children from the United States. The poor dietary patterns reported, have included greater consumption of high energy foods and lower consumption of fruit and vegetables (Kennedy and Powell, 1997). Since healthy foods such as fruit and vegetables, poultry, fish and whole grain food items cost more, less healthy alternatives such as refined grain, fried potatoes, bakery products, and snacks containing high sugar and fat, were found to be common in lower socio-economic status communities (Moore and Diez Roux, 2006). In contrast, in this study, higher socioeconomic class was related to the consumption of higher total energy and animal fat, although a higher proportion of adequate micronutrient intake (ie. vitamin group B, calcium and zinc) was seen in children from higher socioeconomic status.

Caution should be used when interpreting the findings of this study due to a number of limitations. It is known that FFQs are designed to estimate an individual's usual intake of food. Thus, they are suitable for ranking subjects according to food or nutrient intake rather than for estimating the levels of intake (Thompson and Byers, 1994). Furthermore, findings from validation studies of the FFQs for measuring dietary habits of young children have shown that FFQs overestimate the mean energy intake by 0.2% to 25% (Blum et al., 1999, Wilson and Lewis, 2004) and this could also be the case for this child population. However, the interpretation was based on the mean nutrient intakes, expressed as percentage of energy from macronutrients, rather than the absolute levels of intake. Additionally, comparison of nutrient intake across different groups has relied on the ranking characteristic of dietary data collected from the FFQs. These would minimise this limitation.

Another important issue for FFQ data is that it is collected by self-reporters (ie. parents and teachers). Methods have been proposed to identify under-reporting of nutrient intake such as using the Goldberg cut-off (Black, 2000) or using standard equations based on BMR to estimate the range of energy intake in children (Torun et al., 1996). However, they were not suitable for use in this study since the dietary data collected by the FFQs did not measure the level of intake. Thus, the biases due to under-reporting were not addressed in this study.

In conclusion, the findings of this study indicate an imbalance in dietary patterns in this child population in HCMC. There was higher than recommended protein and fat consumption, particularly animal protein and fat intake and lower levels of carbohydrate consumption. Almost all the children in the study had a diet with the percentage of energy from protein and animal fat exceeding the recommendations. Such problems in food habits appear to be more evident among boys than girls. Although there was some impact of community and household level economic status on the food intake patterns, high protein and fat consumption was similar across different economic status groups. The weaknesses of this study have underlined a need for further examination to monitor changes in dietary patterns and provide evidence for developing healthy eating programs in the future, as a part of an obesity prevention program for young children in HCMC.

Chapter 8 Risk factors for change in adiposity indicators

8.1 Introduction

Evidence from the scientific literature indicates that childhood obesity is becoming a major public health issue in many developing countries in Latin America, the Middle East and Asia. Effective prevention and treatment is urgently required in these areas (Lobstein et al., 2004). Due to the importance of this epidemic for both long and short term health outcomes, as well as the economic burden from the expected substantial increase in obesity-related chronic disease healthcare costs later in life, it is recommended that prevention should commence early in childhood (Lobstein et al., 2004). It is also widely accepted that one of the key points for developing an effective prevention program is to identify the determinants of obesity (Swinburn et al., 2005). The aetiology of childhood obesity is multi-factorial and includes the child's biological characteristics, such as age and gender, their food habits, physical activity behaviour, their genetic make up, and their social and physical environments (WHO, 2000).

Environmental factors are believed to be responsible for the childhood obesity epidemic by promoting a diet containing excess energy, and a lifestyle with low energy utilization (Dietz and Gortmaker, 2001). At the family environment level, obese parents not only transmit a genetic tendency to obesity, but they may also provide an obesogenic environment to their offspring. In addition, dietary and physical activity patterns that lead to positive energy imbalance are associated with parental cognitive stimulation, and socioeconomic status. In developed countries, low income families tend to have fewer safe places for their children to be physically active (Strauss and Knight, 1999, Gordon-Larsen et al., 2006) as well as a lack of consistent access to healthy food choices such as fruits and vegetables (Xie et al., 2003). In contrast, children from high socioeconomic classes in developing countries are more likely to become overweight or obese compared with their counterparts from lower socioeconomic classes (Sakamoto et al., 2001, Hong, 2005). Profound changes in the community context, characterized by the wide availability of sedentary entertainment and high energy-dense foods, have promoted a rapid increase in overweight and obesity over the past few decades through increasing sedentary behaviour and excess food intake (Hill and Peters, 1998).

However, research findings also suggest a strong genetic contribution in some children, making them more susceptible to weight gain in response to changes in the environment (Bell et al., 2005). A four-year cohort study examining the genetic and environment contribution to the phenotypic variation in obesity in Hispanic children aged 4 to 19 years, has indicated a strong genetic contribution to the high prevalence of obesity in this population (Butte et al., 2006). The heritability of anthropometric indexes ranged from 0.24 to 0.75, body composition traits ranged from 0.18 to 0.35, and diet and physical activity presented heritability of 0.32 to 0.69 (Butte et al., 2006). Furthermore, studies on a lifecycle perspective of obesity development have underscored the foetal origin, as well as the child's growth patterns in early life, in the subsequent development of obesity (Oken and Gillman, 2003, Baird et al., 2005, Victora et al., 2007). The web of causation of obesity in childhood is complicated with interaction between genetic, biological, socio-cultural and environmental risk factors, placing the child at risk of overweight.

Current data indicates the growing importance of childhood obesity in Ho Chi Minh City (HCMC), Vietnam, particularly in urban areas. Since comprehensive prevention programs should be evidence-based, studies on the determinants of childhood obesity are needed. Research has described the cross sectional relationships between socio-demographic factors and parental characteristics, and obesity in young children (Hung et al., 2003). Only one study has been carried out with adolescents in HCMC. It focused on hierarchical relationships between contextual factors with individual characteristics in promoting obesity in this population (Hong, 2005). As causal relationships cannot be established in cross sectional studies, it is necessary to perform a longitudinal study to confirm the findings from cross sectional studies on obesity in young populations in HCMC. This chapter aims to identify the risk factors associated with changes in adiposity indicators (BMI, skinfold thickness) and overweight/ obesity over one year of follow-up using an hierarchical conceptual framework of risk factors at community, preschool and family environments, and individual parental and child characteristics.

8.2 Methodology

The survey methods and measurements in the follow-up study have been described in detail in Chapter 3. Briefly, the data collection is summarised in Table 8-1 below:

Table 8-1 Summary of three rounds of data collection

Round	Baseline study (n = 670; conducted from March to April, 2005)	Second round (n = 558 (83.3%); conducted from September to October, 2005)	Third round (n = 526 (78.5%); conducted from March to April, 2006)
Measurements	Anthropometry	Anthropometry	Anthropometry
	Dietary intake	Dietary intake	Dietary intake
	Physical activity	Physical activity	Physical activity
	Socio-demographic information		
	Home environment		
	School environment		

The analytical approaches used to analyse longitudinal data are presented in this chapter.

Statistical analysis

Analyses were performed using STATA version 9 (2005, Stata Corporation, College Station, TX, USA). Descriptive results including anthropometric measurements, dietary intake and physical activity assessments over the three data collection rounds, were described by means and standard deviations. The prevalence of overweight, obesity, and underweight and associated 95% confidence intervals (CIs) using the IOTF definitions(Cole et al., 2000) were calculated. Student's *t* test was used to compare group differences of continuous variables. The Stata "svyset" commands, which use Taylor linearized variance estimation, adjusted the analyses for the stratified two-stage cluster sampling design.

In this study, a range of measures including BMI, skinfold thickness at triceps, subscapular and suprailiac sites with the raw value, were used as approximate measures of adiposity. The accurate raw values of skinfold thickness have been reported to be confounded when using prediction equations under some assumptions, to provide estimates of body fat (Wells and Fewtrell, 2006). Since it was suggested that the use of multiple skinfolds gave more reliable results about body fat in the subcutaneous fat layer (Willett, 1998a), the sum of triceps, subscapular and suprailiac skinfold thicknesses along with the single measures was used as an estimation of body fatness in this study.

Employing the BMI classification system developed by the IOTF to define overweight and obesity (Cole et al., 2000), has set up age and gender specific cut-off points that pass through the BMI adult cut off points of 25 and 30 kg/m^2 for overweight and obesity respectively at the age of 18 years-the cut off points associated with an increased risk of adverse health outcomes in adults. These points were selected for a number of reasons. Their use allows international comparisons of obesity prevalence because this classification system has been used worldwide for defining obesity in children. The association between childhood obesity and illness risks has not been well established and in the absence of this information, a classification system linked to cut off points defining adult health risks seems to be a reasonable compromise.

Generalized estimating equations (GEE) using an exchangeable correlation structure were employed to assess the longitudinal relationship between the development of body fatness (BMI, skinfold thickness), overweight and obesity and the predictors measured at three different time-points over one year in univariate and multivariate analyses, with robust standard error estimation (Twisk, 2003). The estimated regression coefficients reflect the relationship between the longitudinal development of adiposity, overweight and obesity along with the longitudinal development of the corresponding predictors of interest, using all available longitudinal data such as food intake and physical activity (Twisk, 2003).

Initially, univariate analysis was carried out for all variables. Then, individual variables were included in the model based on an hierarchical modeling strategy in which variables were placed into hierarchies using a conceptual framework (see Figure 8.1) of risk factors for the development of overweight and obesity in young children (Victora et al., 1997). Using this approach, the choice of variables included in the model moves beyond entirely statistical considerations, and more strongly associates with the outcomes of interest. In addition, the development of overweight and obesity in this child population was explained by a hierarchical inter-relationship between risk factors from individual factors and contextual environment factors.

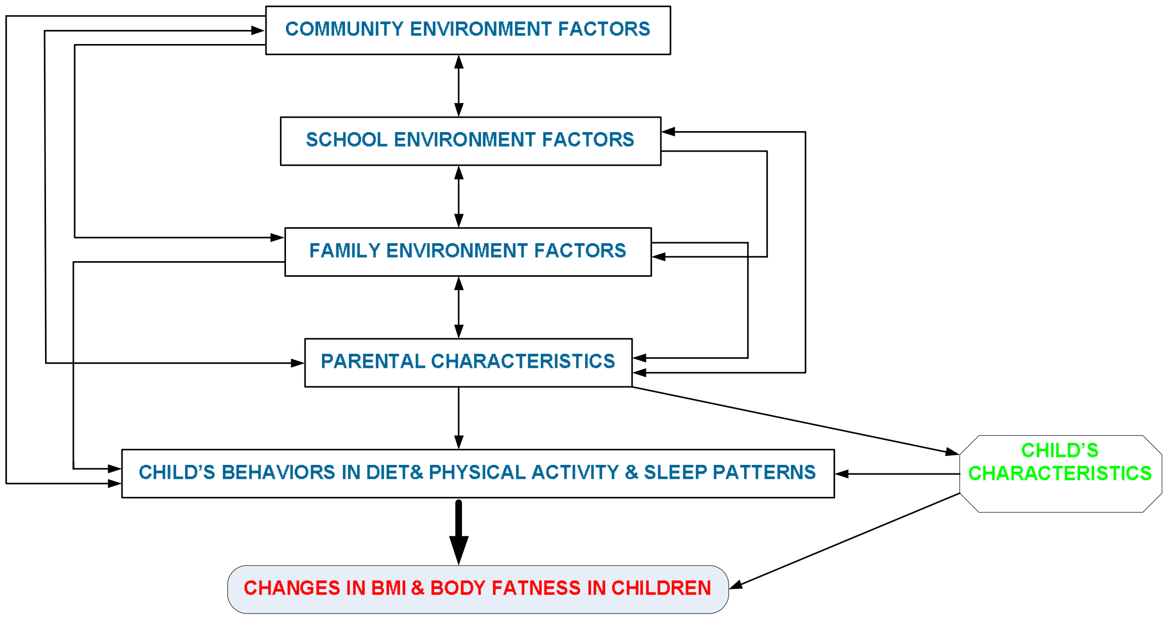


Figure 8-1 Hierarchical conceptual framework of determinants for changes in BMI and body fatness over time
Sources (Victora et al., 1997, Davison and Birch, 2001b)

Six levels of risk factors in this conceptual framework were considered. At the community level, obesity-promoting neighbourhood factors were considered. They consisted of place of residence located in wealthy districts or less wealthy districts, accessibility to Western style and local fast food stores, availability of video/computer game shops, play grounds and the parental perception on safety in the neighbourhood.

As physical education and activities during break times in all preschools follow the recommended programs from the Department of Education, these factors were not different among the selected preschools. Thus, only the following factors at the preschool level were considered; the size of the play ground, the size of the class room, and the number of items of play equipment. A preschool food environment score was calculated from information assessing the availability of snack foods, sweets, and ice-cream in the vicinity of the preschool, using factor analysis. Using this approach, the least number of factors which can account for the common variance (correlation) of a set of variables was identified. The score was equally divided in tertiles.

The factors of interest for the family environment comprised the household wealth index, scores of cognitive stimulation of the child's environment, the emotional relationship between parents and child, and a home food environment score. These scores were ranked and grouped into tertiles.

There were four factors at the level of parental characteristics, including parental BMI, education and occupation. Maternal pre-pregnant BMI status for the studied child was also included in this level.

Child behaviour, relating to food intake, physical activity, and sleep patterns was examined. Duration of breast feeding, dietary intake of specific nutrients, and physical activity patterns such as time spent on sedentary behaviour (including TV viewing), and vigorous activity, and the average amount of time asleep at night, were included. Intake of each nutrient examined was grouped using tertiles. Physical activity was analysed as a continuous variable.

At the level of child characteristics, factors of interest were the weight at birth, self-reported diagnosis of gestational diabetes, self-reported maternal weight gain during pregnancy, birth order, and only child status. Variables at each level were summarised in Table 8-2.

Table 8-2 Summary of variables at each level of risk factors

Sequent steps in model building	Levels	Variables
1	Community environment	Economic level of districts Availability of play ground nearby Safety of environment Game shop nearby Fast food restaurant nearby Local fat food shop nearby
2	School environment	School yard Average size of school yard Number of children in relation with number of teachers Number of play equipments School food environment scores
3	Family environment	Wealth index Cognitive scores Emotional scores Having own television Having gamemachine at home Home food environment scores
4	Parental characteristics	Parental BMI status Father education level Mother education level Paternal occupations Maternal occupations
5	Child's dietary, PA behaviours, sleep pattern	Duration of breast feeding (months) Duration of sleeping (hours) Energy (kcal) Macro-nutrients Protein (g) Fat (g) Carbohydrate (g) Frequency of softdrink consumption Frequency of icecream consumption Frequency of fast food Sedentary time (hours) TV viewing (hours) Vigorous activities (hours)
6	Child's characterisitcs	Age (month) Gender Birth weight (100 g) Only child Birth order

The time period of the study was also one of the predictors in the models for changes in BMI, skinfold thickness and overweight and obesity. Time was added as a continuous variable at the first step of modeling and coded as [1, 2, 3]. Interactions between time and gender and between parental education and household wealth index were added at the final step of modeling.

Distal variables, such as community factors, might directly affect the outcomes of interest or be mediated through other proximate determinants including the preschool environment, family characteristics and child's dietary and physical activity behaviour. This hierarchical conceptual framework between these risk factors is illustrated in Figure 8.1.

Modeling followed the sequence of levels shown in the conceptual framework. Variables within each level of the hierarchical model were included and the variables with the highest non-significant p values ($p \geq 0.05$) were manually removed, one at a time. Only the statistically significant variables (based on the Wald statistic) or variables of established biologic importance in each level, were kept in the model for subsequent analysis in the next level. Furthermore, basic characteristics such as age, gender and time, were included at the beginning of modeling process and left in all models. For example, the variables at community level, along with age, gender and time, were examined in the first step of modeling. Only the variables significantly associated with the outcomes ($p<0.05$) were retained for next step of the modeling. Note that age, gender and time were left in the model regardless of statistical significance because they were considered to be confounding variables. Preschool environment variables were subsequently added and only those significantly associated with the outcomes were kept. Similarly, the family environment level variables were examined next. A similar procedure was repeated for all other levels.

For the continuous outcomes, including BMI and skinfold thicknesses, the adjusted regression coefficients and the 95% CIs presented, were derived from the GEE models, corresponding to the level at which the factors were first entered. The reason for not using the coefficients derived from the final model was that the role of the distal determinants might be diminished due to mediating factors in more proximal levels, and the effects of distal variables should be analysed without these proximate determinants. Similarly, the adjusted relative risks and the 95% CIs for dichotomous outcomes, such as overweight and obesity, were derived from GEE models using a similar approach.

8.3 Results

Of the 670 cohort participants, 526 children completed three measurements over the year of follow-up (78.5%), with 49% being boys. The results are presented in two parts. Part A presents the descriptive findings on anthropometric measurements, dietary intake, and physical activity of the participants at each of the three rounds over the one year of follow-up. The combined gender models and gender specific models of determinants predicting changes in adiposity including BMI, individual and sum of skinfold thickness are presented in Part B.

8.3.1 Part A: Characteristics of participants at three measurements

Comparison of biological characteristics such as age, gender and anthropometric measurements including weight, height, BMI, BMI Z-scores, triceps, subscapular and suprailiac skinfold thicknesses of children who participated in the follow-up and those who did not participate in the follow-up, are presented in Table 8-3. Weight, height, BMI and BMI Z-scores in both groups were normally distributed at each of the three rounds. The distributions of skinfold thickness measurements were slightly skewed. There were no statistically significant differences between participants and non-participants, in any of the characteristic examined.

Table 8-3 Mean age, weight, height, BMI, BMI Z-scores and skinfold thickness among participants and non-participants

Mean, standard deviation and the 95% confidence intervals for age, weight, height, BMI, BMI Z-scores and skinfold thickness among participants and non-participants at follow-up measurements

Characteristics	Participating in first follow-up (n = 558)			Not participating in first follow-up (n = 112)			Participating in second follow-up (n = 526)			Not participating in second follow-up (n = 32)		
	Mean	± SD	95% CI	Mean	± SD	95% CI	Mean	± SD	95% CI	Mean	± SD	95% CI
Age (months)	56.3	3.6	—	55.6	3.5	—	62.6	3.6	—	62.6	3.3	—
Weight (kg)	19.6	3.7	19.0, 19.9	19.6	4.0	18.9, 20.2	21.3	4.1	20.7, 21.7	20.6	3.9	19.3, 21.4
Height (cm)	107.3	4.9	106.6, 107.6	107.0	5.2	105.9, 107.9	111.1	5.0	110.4, 111.5	110.2	4.5	108.3, 111.5
BMI (kg/m²)	16.9	2.2	16.6, 17.1	17.0	2.46	16.6, 17.4	17.1	2.4	16.8, 17.4	16.8	2.3	16.1, 17.3
BMI Z-scores	0.8	1.3	0.7, 0.9	0.9	1.3	0.6, 1.1	0.9	1.3	0.7, 1.0	0.7	1.3	0.3, 1.0
Triceps SF (mm)	11.0	3.4	10.4, 11.4	11.2	3.6	10.7, 11.8	12.2	4.1	11.8, 12.6	11.1	4.3	9.9, 12.3
Subscapular SF (mm)	8.5	3.7	8.0, 8.9	8.7	4.5	8.0, 9.4	9.2	4.5	8.6, 9.7	8.6	4.5	7.2, 9.9
Suprailiac SF (mm)	9.4	4.3	8.9, 10.0	9.6	4.5	8.8, 10.4	10.7	4.9	10.2, 11.2	9.7	5.1	8.4, 11.1
Sum of SFs (mm)	28.7	10.9	27.4, 29.95	29.6	11.8	27.8, 31.4	32.1	13.3	30.7, 33.5	29.5	13.6	25.8, 33.2

— *Data were not available*

Table 8-4 describes the child characteristics of age, gender, weight, height, BMI and BMI Z-scores separately for boys and girls who participated in each round of measurement. The mean ages of children of both genders at each of the three measurements were not significantly different. Boys were heavier than girls at all three measurements. At the baseline, the mean height of boys was statistically significantly higher than that of girls ($p=0.0126$). However, there was no significant difference in height between boys and girls in subsequent measurements. Mean BMI and BMI Z-scores in boys were statistically significantly higher than in girls over the one year of follow-up.

Table 8-4 Mean age, weight, height, BMI and BMI Z-score by gender

Mean, standard deviation and 95% confidence intervals for age, weight, height, BMI and BMI Z-scores by gender at the baseline and the follow-up measurements

Measurements	Boys (n = 333)			Girls (n = 337)			p-value[1]
	Mean	SD	95% CI	Mean	SD	95% CI	
Baseline study							
Age (months)	56.1	3.6	_	56.3	3.5	_	0.514
Weight (kg)	20.1	4.0	19.4, 20.7	18.9	3.3	18.3, 19.5	0.000
Height (cm)	107.6	4.9	106.9, 108.2	106.6	4.9	105.9, 107.3	0.012
BMI (kg/m²)	17.2	2.4	16.9, 17.6	16.6	2.0	16.2, 16.9	0.000
BMI Z-score	1.0	1.41	0.77, 1.19	0.64	1.15	0.46, 0.79	0.000
First follow-up	Boys (n = 274)			Girls (n = 284)			
Age (months)	62.4	3.67	_	62.7	3.5	_	0.295
Weight (kg)	21.9	4.4	21.1, 22.6	20.5	3.6	19.8, 21.0	0.000
Height (cm)	111.2	5.0	110.5, 111.9	110.7	4.9	109.8, 111.3	0.125
BMI (kg/m²)	17.6	2.58	17.2, 18.0	16.6	2.0	16.3, 16.9	0.000
BMI Z-score	1.1	1.36	0.88, 1.27	0.66	1.15	0.47, 0.78	0.000
Second follow-up	Boys (n = 257)			Girls (n = 269)			
Age (months)	67.8	3.7	_	70.0	3.46	_	0.560
Weight (kg)	23.4	4.7	22.6, 24.1	21.9	3.8	21.2, 22.4	0.000
Height (cm)	114.1	5.2	113.3, 114.8	113.5	5.0	112.7, 114.2	0.189
BMI (kg/m²)	17.8	2.6	17.4, 18.2	16.9	2.1	16.5, 17.1	0.000
BMI Z-score	1.2	1.18	0.77, 1.19	0.73	1.10	0.46, 0.79	0.000

[1]p-value was calculated from Student's t-test
- Data were not available

The description of the triceps, subscapular, and suprailiac skinfold thickness measurements by gender over the one year period are shown in Table 8-5. There were no statistically significant gender differences in triceps and suprailiac skinfold thicknesses for each of the three measurements, except for subscapular skinfold thickness at the baseline measurement.

Table 8-5 Mean triceps, subscapular, and suprailiac skinfold thicknesses by gender

Mean, standard deviation, median and the 95% confidence intervals for triceps, subscapular and suprailiac skinfold thicknesses by gender at the baseline and the follow-up measurements

Measurements	Boys (n = 333)				Girls (n = 337)				p-value[1]
	Mean	SD	Median	95% CI	Mean	SD	Median	95% CI	
Baseline study									
Triceps SF (mm)	10.8	3.7	9.9	10.3, 11.3	11.2	3.2	10.8	10.6, 11.8	0.140
Subscapular SF (mm)	8.3	4.1	6.9	7.8, 8.8	8.7	3.6	7.5	8.1, 9.3	0.019
Suprailiac SF (mm)	9.4	4.6	8.1	8.7, 10.1	9.6	4.1	8.4	8.8, 10.3	0.592
Sum of SFs (mm)	28.3	11.7	24.3	26.7, 29.9	29.4	10.4	27	27.6, 31.2	0.302
First Follow-up	Boys (n = 274)				Girls (n = 284)				
Triceps SF (mm)	12.1	4.6	11	11.5, 12.7	12.1	3.6	11.6	11.6, 12.6	0.761
Subscapular SF (mm)	9.3	4.9	7.3	8.5, 10.0	9.1	3.8	8.0	8.3, 9.8	0.091
Suprailiac SF (mm)	10.7	5.4	9.4	9.9, 11.4	10.7	4.4	9.7	10.1, 11.3	0.864
Sum of SFs (mm)	32.3	15.0	27.7	30.2, 34.2	32.1	11.6	29.3	30.1, 33.5	0.802
Second Follow-up	Boys (n = 257)				Girls (n = 269)				
Triceps SF (mm)	12.8	4.7	12.2	12.1, 13.5	13.0	0.9	12.7	12.5, 13.4	0.590
Subscapular SF (mm)	9.7	4.8	8.1	8.8, 10.5	9.6	3.9	8.6	9.0, 10.2	0.264
Suprailiac SF (mm)	11.6	5.5	9.7	10.8, 12.3	11.5	4.7	10.2	11.0, 12.0	0.996
Sum of SFs (mm)	34.2	14.5	31.0	31.8, 36.1	34.1	11.7	32.3	32.5, 35.1	0.905

[1]p-value was calculated from Student's t-test

Table 8-6 shows the changes in weight, height, BMI and BMI Z-scores over time by gender. During the first six months, boys gained more weight than girls, while a similar increase in height was observed in both genders. These differences were statistically significant. Thus, higher increases in BMI and BMI Z-scores were seen in boys than in girls. In the second six months, changes in weight, height, BMI and BMI Z-scores were not statistically significantly different between the genders. Therefore, the significant changes in weight, height, BMI and BMI Z-scores over the one year period were from changes in the first six months.

Table 8-6 Changes in weight, height, BMI and BMI Z-scores

Mean, standard deviation and the 95% confidence intervals for the changes in weight, height, BMI and BMI Z-scores by gender at the baseline and the follow-up measurements

Characteristics	Boys (N = 274)			Girls (N = 284)			p-value[1]
	Mean	± SD	95% CI	Mean	± SD	95% CI	
Changes in anthropometric measurements between first follow-up and baseline							
ΔWeight (kg)	1.84	1.06	1.68, 1.99	1.47	0.95	1.31, 1.64	0.000
ΔHeight (cm)	3.76	0.68	3.60, 3.91	3.84	0.68	3.69, 3.98	0.482
ΔBMI (kg/m²)	0.33	0.78	0.19, 0.47	0.07	0.78	-0.09, 0.23	0.000
ΔBMI Z-scores	0.10	0.46	0.02, 0.19	0.01	0.44	-0.08, 0.10	0.017
Changes in anthropometric measurements between second and first follow-ups							
ΔWeight (kg)	1.44	0.95	1.30, 1.62	1.37	0.90	1.23, 1.45	0.391
ΔHeight (cm)	2.77	0.67	2.58, 2.95	2.84	0.79	2.63, 3.03	0.273
ΔBMI (kg/m²)	0.25	0.71	0.14, 0.34	0.23	0.68	0.13, 0.32	0.749
ΔBMI Z-scores	0.07	0.41	-0.002, 0.12	0.07	0.37	0.02, 0.12	0.749
Changes in anthropometric measurements between second and baseline							
ΔWeight (kg)	3.31	1.48	3.12, 3.51	2.86	1.33	2.6, 3.0	0.000
ΔHeight (cm)	6.60	0.92	6.33, 6.82	6.70	0.96	6.5, 6.9	0.179
ΔBMI (kg/m²)	0.60	0.99	0.44, 0.70	0.32	0.94	0.16, 0.42	0.001
ΔBMI Z-scores	0.18	0.59	0.07, 0.27	0.09	0.51	0.004, 0.14	0.001

[1]p-value was calculated from Student's t-test

As shown in Table 8-7, changes in triceps and subscapular skinfold thicknesses in boys in the first six months were significantly higher than in girls, except for suprailiac skin fold thickness which was not statistically significant. There were no statistically significant changes in skinfold thickness measurements between genders in the second six months as well as over the one year period.

Table 8-7 Changes in skinfold thickness by gender

Mean, standard deviation and the 95% confidence intervals for the changes in triceps, subscapular, suprailiac skinfold thickness by gender at the baseline and the follows-up measurements

Measurements	Boys (N = 274)			Girls (N = 284)			p-value[1]
	Mean	± SD	95% CI	Mean	± SD	95% CI	
Changes in anthropometric measurements between first follow-up and baseline							
∆Triceps SF (mm)	1.37	1.84	1.05, 1.69	0.94	1.65	0.63, 1.26	0.006
∆Subscapular SF (mm)	1.01	1.56	0.70, 1.32	0.39	1.56	0.10, 0.73	0.001
∆Suprailiac SF (mm)	1.34	1.96	0.97, 1.70	1.11	1.81	0.75, 1.47	0.334
∆ sum of SFs (mm)	4.07	5.83	3.29, 4.86	2.44	5.43	1.69, 3.19	0.002
Changes in anthropometric measurements between second and first follow-ups							
∆Triceps SF (mm)	0.65	1.41	0.41, 0.89	0.80	1.49	0.57, 1.03	0.141
∆Subscapular SF (mm)	0.32	1.31	-0.09, 0.74	0.50	1.47	0.03, 0.96	0.095
∆Suprailiac SF (mm)	0.79	1.81	0.47, 1.10	0.80	2.59	0.39, 1.20	0.866
∆ sum of SFs (mm)	1.38	5.08	0.45, 2.31	2.01	5.25	1.04, 2.98	0.178
Changes in anthropometric measurements between second follow-up and baseline							
∆Triceps SF (mm)	2.04	2.26	1.59, 2.49	1.74	2.14	1.41, 2.07	0.199
∆Subscapular SF (mm)	1.32	2.33	0.80, 1.83	0.88	2.12	0.48, 1.28	0.061
∆Suprailiac SF (mm)	2.16	2.38	1.80, 2.52	1.92	2.41	1.39, 2.44	0.441
∆ sum of SFs (mm)	5.63	6.37	4.63, 6.64	4.47	6.33	3.47, 5.48	0.066

[1]*p-value was calculated from Student's t-test*

Table 8-8 reveals the changes in weight, height, BMI and BMI Z-scores by groups of districts during the one year follow-up. Children from wealthy districts experienced a significant change in weight over the first six months compared with those from less wealthy districts. In contrast, a statistically significant increase in height was seen in the children from less wealthy districts compared with wealthy districts. As a result, the changes in BMI and BMI Z-scores in children from wealthy district groups were significantly higher than those from less wealthy districts. These patterns of changes in weight, height, BMI and BMI Z-scores were similar for the second six months as well as over the one year of follow-up, although change in the children's height in the two groups of districts were not significantly different.

Table 8-8 Changes in weight, height, BMI and BMI Z-scores by groups of districts

Mean, standard deviation and the 95% confidence intervals for the changes in weight, height, BMI and BMI Z-scores by groups of districts at the baseline and the follow-up measurements

Characteristics	Wealthy Districts			Less wealthy districts			p-value[1]
	Mean	± SD	95% CI	Mean	± SD	95% CI	
Changes in anthropometric measurements between first follow-up and baseline							
∆Weight (kg)	1.72	1.03	1.47, 1.97	1.62	1.01	1.44, 1.79	0.035
∆Height (cm)	3.74	0.66	3.55, 3.94	3.83	0.69	3.64, 4.01	0.014
∆BMI (kg/m²)	0.25	0.79	0.04, 0.46	0.17	0.78	-0.01, 0.35	0.022
∆BMI Z-score	0.09	0.46	-0.04, 0.22	0.03	0.44	-0.07, 0.13	0.005
Changes in anthropometric measurements between second and first follow-ups							
∆Weight (kg)	1.50	0.99	1.31, 1.69	1.31	0.85	1.23, 1.39	0.000
∆Height (cm)	2.84	0.74	2.64, 3.04	2.78	0.74	2.49, 3.07	0.094
∆BMI (kg/m²)	0.30	0.73	0.17, 0.42	0.19	0.65	0.11, 0.27	0.002
∆BMI Z-score	0.09	0.41	0.02, 0.15	0.05	0.36	0.0002, 0.11	0.066
Changes in anthropometric measurements between second follow-up and baseline							
∆Weight (kg)	3.21	1.46	2.97, 3.45	2.94	1.37	2.73, 3.15	0.000
∆Height (cm)	6.59	0.94	6.32, 6.85	6.63	0.95	6.32, 6.94	0.361
∆BMI (kg/m²)	0.55	1.00	0.36, 0.73	0.36	0.95	0.22, 0.50	0.000
∆BMI Z-score	0.18	0.57	0.05, 0.31	0.09	0.53	0.005, 0.17	0.001

[1]p-value was calculated from Student's t-test

The changes in skinfold thickness measurements over one year are shown in Table 8-9. Children from wealthy districts demonstrated a significantly greater increase in triceps at each of the three intervals examined, compared with those from less wealthy districts. Subscapular skinfold thickness measurements were not significantly different between the two groups over the first six months, but in the second six months, there was a significant increase in this skinfold thickness measurement of those from wealthy districts compared with those from less wealthy districts. A greater increase in suprailiac skinfold thickness was seen in children from wealthy districts during the first six months but this was not evident in the later six months, or over the one year of the study.

Table 8-9 Changes in skinfold thickness measurements by groups of districts

Mean, standard deviation and the 95% confidence intervals for the changes in triceps, subscapular, suprailiac skinfold thicknesses by groups of districts at the baseline and follow-up measurements

Characteristics	Wealthy Districts			Less wealthy districts			p-value[1]
	Mean	± SD	95% CI	Mean	± SD	95% CI	
Changes in anthropometric measurements between first follow-up and baseline							
∆Triceps SF (mm)	1.26	2.25	0.86, 1.65	0.90	2.02	0.36, 1.45	0.000
∆Subscapular SF (mm)	0.64	1.56	0.25, 1.02	0.73	2.01	0.31, 1.15	0.328
∆Suprailiac SF (mm)	1.73	2.98	0.55, 2.92	1.43	2.84	0.54, 2.31	0.034
∆ sum of SFs (mm)	4.71	6.66	2.28, 7.14	3.74	7.07	2.25, 5.24	0.102
Changes in anthropometric measurements between second and first follow-ups							
∆Triceps SF (mm)	2.16	2.55	1.62, 2.70	1.55	2.37	1.02, 2.08	0.000
∆Subscapular SF (mm)	0.71	1.86	0.31, 1.11	0.21	1.95	-0.44, 0.85	0.002
∆Suprailiac SF (mm)	0.50	2.75	-0.34, 1.34	0.65	2.57	-0.21, 1.50	0.291
∆ sum of SFs (mm)	1.92	5.96	0.22, 3.67	1.89	6.63	0.35, 3.43	0.959
Changes in anthropometric measurements between second follow-up and baseline							
∆Triceps SF (mm)	2.16	2.26	1.62, 2.70	1.55	2.37	1.02, 2.08	0.000
∆Subscapular SF (mm)	1.34	2.30	0.75, 1.93	0.96	2.15	0.39, 1.53	0.050
∆Suprailiac SF (mm)	2.23	2.38	1.34, 3.12	2.16	2.89	1.34, 2.98	0.653
∆ sum of SFs (mm)	6.63	7.28	4.92, 8.33	5.85	7.56	4.42, 7.28	0.239

[1]*p-value was calculated from Student's t-test*

Table 8-10 summarises the significant changes in anthropometric measurements in children over the one year period, as presented from Table 8-6 to Table 8-9.

Table 8-10 Summary of significant changes in anthropometric measurements

Characteristics	Boys vs. Girls	Wealthy vs. Less wealthy districts
Changes in anthropometric measurements between first follow-up and baseline		
∆Weight (kg)	↑	↑
∆Height (cm)	≈	↑
∆BMI (kg/m²)	↑	↑
∆BMI Z-scores	↑	↑
∆Triceps SF (mm)	↑	↑
∆Subscapular SF (mm)	↑	≈
∆Suprailiac SF (mm)	≈	↑
∆ Sum of SFs (mm)	↑	≈
Changes in anthropometric measurements between second and first follow-ups		
∆Weight (kg)	≈	↑
∆Height (cm)	≈	≈
∆BMI (kg/m²)	≈	↑
∆BMI Z-scores	≈	≈
∆Triceps SF (mm)	≈	↑
∆Subscapular SF (mm)	≈	↑
∆Suprailiac SF (mm)	≈	≈
∆ Sum of SFs (mm)	≈	≈
Changes in anthropometric measurements between second and baseline		
∆Weight (kg)	↑	↑
∆Height (cm)	≈	≈
∆BMI (kg/m²)	↑	↑
∆BMI Z-scores	↑	↑
∆Triceps SF (mm)	≈	↑
∆Subscapular SF (mm)	≈	≈
∆Suprailiac SF (mm)	≈	≈
∆ Sum of SFs (mm)	≈	≈

↑ *significant increase*
≈ *not significant difference*

Table 8-11 presents the mean nutrient intake of boys and girls, and reveals that boys consumed significantly higher levels of nutrients than girls at each of the measurements.

Table 8-11 Dietary intake of children at baseline and follow-up measurements by gender

Mean, standard deviation and the 95% confidence intervals for energy and macronutrients by gender at the baseline and the follow-up measurements

Measurements	Boys (N = 333)			Girls (N = 337)			p-value[1]
	Mean	± SD	95% CI	Mean	± SD	95% CI	
Baseline							
Energy (kcal)	1647.0	401.0	1598.0, 1695.0	1560.0	398.0	1526.0, 1593.0	0.004
Protein (g)	75.7	19.1	73.9, 77.5	72.1	20.1	70.4, 73.8	0.011
Lipid (g)	39.3	11.8	37.6, 40.9	37.5	12.1	36.3, 38.6	0.051
Carbohydrate (g)	248.0	61.7	240.0, 256.0	234.0	58.4	228.0, 240.0	0.002
First Follow-up							
Energy (kcal)	1689.0	375.1	1629.0, 1748.0	1593.0	389.0	1528.0, 1659.0	0.002
Protein (g)	77.0	19.5	73.9, 80.1	74.2	19.7	70.9, 77.6	0.039
Lipid (g)	39.9	11.6	38.3, 41.5	37.8	10.9	36.1, 39.5	0.017
Carbohydrate (g)	256.0	55.9	246.0, 266.0	239.0	59.7	229.0, 250.0	0.000
Second Follow-up							
Energy (kcal)	1663.0	411.0	1605.0, 1721.0	1523.0	402.0	1473.0, 1573.0	0.000
Protein (g)	75.8	20.5	72.7, 78.9	69.8	20.3	67.1, 72.5	0.000
Lipid (g)	39.2	12.4	37.1, 41.3	35.8	11.4	34.2, 37.3	0.000
Carbohydrate (g)	252.0	62.1	244.0, 260.0	231.0	61.0	223.0, 238.0	0.000

[1]p-value was calculated from Student's t-test

A description of physical activity by gender at each of the three measurements is shown in Table 8-12. There was a gender difference for time spent in vigorous activity, where boys spent significantly more time being vigorously active than girls and this pattern was consistent at each follow-up. The time spent in sedentary behaviour was not significantly different between boys and girls at each of the three measurements, however in the third measurement, boys were reported to spend more time viewing TV than girls (p=0.0379).

Table 8-12 Physical activity of children at baseline and follow-up measurements by gender

Mean, standard deviation and the 95% confidence intervals for sedentary behaviour, vigorous activity, duration of TV viewing by gender at the baseline and follow-up measurements

Measurements	Boys			Girls			p value[1]
	Mean	SD	95% CI	Mean	SD	95% CI	
Baseline (n = 670)							
Sedentary activities (h)	6.56	1.67	6.16, 6.97	6.62	1.52	6.29, 6.95	0.827
Vigorous activities (h)	2.24	1.12	2.05, 2.42	1.73	1.13	1.50, 1.96	0.000
TV viewing (h)	1.45	0.88	1.35, 1.55	1.35	0.81	1.23, 1.46	0.113
First Follow-up (n = 558)							
Sedentary activities (h)	6.00	1.26	5.81, 6.19	5.99	1.29	5.85, 6.13	0.761
Vigorous activities (h)	1.63	0.77	1.54, 1.72	1.37	0.74	1.27, 1.48	0.000
TV viewing (h)	1.80	0.78	1.69, 1.90	1.46	0.77	1.36, 1.57	0.244
Second Follow-up (n = 526)							
Sedentary activities (h)	6.60	1.46	6.29, 6.90	6.54	1.35	6.31, 6.77	0.514
Vigorous activities (h)	1.95	0.84	1.76, 2.14	1.62	0.88	1.45, 1.79	0.000
TV viewing (h)	1.64	0.84	1.52, 1.75	1.50	0.75	1.42, 1.58	0.037

[1]p-value was calculated from Student's t-test

Table 8-13 examines the prevalence of overweight and obesity in both genders at each of the three measurements over the year of follow-up. The prevalence of overweight was not significantly different between boys and girls. However, the prevalence of obesity in boys was statistically significantly higher than in girls and this was consistent at each of the measurements (p=0.0008, 0.0002, 0.0006 respectively). The prevalence of overweight in boys significantly increased over the one year of follow-up (p=0.0189) but not for girls (p=0.210). Overall, the percentage of children classified as overweight at the end of the study was significantly higher compared with that at the baseline (p=0.0020).

Table 8-13 Prevalence of overweight and obesity at baseline and follow-up

Percentage and 95% confidence intervals for overweight and obesity in children at the baseline and the follow-up. Overweight and obesity are defined according to IOTF definition (Cole et al., 2000)

Measurements	Number	Overweight		Obesity	
		%	95% CI	%	95% CI
Baseline (n = 670)					
All	670	20.5	17.5, 24.3	16.3	13.2, 20.4
Boys	332	19.1	15.7, 23.1	21.7	16.8, 27.5
Girls	338	21.8	17.3, 27.1	11.1	6.4, 18.3
First Follow-up (n = 558)					
All	558	24.5	21.2, 28.1	16.2	12.9, 20.2
Boys	274	23.0	19.2, 27.3	22.6	16.9, 29.4
Girls	284	25.9	20.3, 32.5	10.0	6.1, 15.8
Second Follow-up (n = 526)					
All	526	28.8	23.9, 34.1	17.5	13.5, 22.3
Boys	257	27.8	22.2, 34.3	24.0	17.2, 32.4
Girls	269	29.7	24.2, 35.9	11.2	7.7, 16.0

8.3.2 Part B: Models of risk factors for changes in adiposity

Table 8-14 presents the effects of interaction between environment factors and individual characteristics on the development of BMI over the one year of study. At the community environment factor level, after adjustment for other variables, (such as resident location, the availability of a play ground nearby, the availability of a games shop and the location of Western and local fast food outlets in the neighborhood), the safety of the neighborhood was found to protect children against a significant increase in BMI over the one year period (coefficient: -0.80, 95% CI: -1.27, -0.03).

Factors at the school environment did not have any influence on the change in BMI over the period of one year after controlling for significant variable in the community level. The un-confounded effects of family environment factors on the development of BMI over one year included the household wealth status, cognitive stimulation, and a good home-food environment. Children who were from the wealthiest households and those who had the highest scores of cognitive encouragement from parents in terms of primary school preparation, reading stories and offering any kind of outing to the child, were more likely to have an increased BMI by 0.94 units (95% CI: 0.49, 1.39) and 0.43 units (95% CI: 0.01, 0.85) respectively during the one year of follow-up. There were dose-response relationships between good home food environment and the change in BMI over time. Children with a higher score of good home food were more likely to have a significant decrease in BMI over the one year period (medium score: -0.55; 95% CI: -0.98, -0.12, highest score: -0.71; 95% CI: -1.13, -0.29).

At the parental characteristic level, compared with children who were born to underweight mothers, those who were born to both normal and overweight mothers were statistically significantly associated with an increased BMI during the one year period of study (coefficients: 0.55, 95% CI: 0.14, 0.95 and 0.66, 95% CI: 0.14, 1.19 respectively). Having both parents overweight at baseline, strongly predicted the change in BMI in children over of follow up (coefficient: 1.38, 95% CI: 0.74, 2.02). However, an overweight mother only, was not significantly associated with the outcome while overweight father only was borderline significantly associated with change in BMI over time (p=0.054). Paternal education levels had an impact on changes in BMI over time in their offspring whilst there was no association between maternal education levels with changes in BMI in their children. Children, whose fathers attained high school and college or university, demonstrated an increased BMI over the one year of study (coefficients: 0.67, 95% CI: 0.07, 1.27 and 0.83, 95% CI: 0.16, 1.50 respectively).

Considering the factors at the child's behavior level in the model, only the effect of duration of breast feeding on the development of BMI remained significant in this level. Each additional month of breast feeding was statistically significantly associated with a reduced BMI by 0.04 units (95% CI: -0.06, -0.02) over the one year of follow-up. There were no significant associations between dietary intake, physical activity, and sleep pattern, and changes in BMI over time in the multivariate analysis.

With regard to the child's characteristics, boys had a significant increase in BMI over the one year compared with girls (coefficient: 0.82, 95% CI: 0.46, 1.17). There was small effect but it was statistically significant between higher birth weight and the change in BMI over the one year of study. Each additional one hundred grams of birth weight statistically significantly predicted an increase of 0.06 units (95% CI: 0.03, 0.10) in BMI. Age in months was not statistically significantly related to the development of BMI over one year.

Including the interaction terms in the final model, the interaction between the time of study and gender was statistically significant ($p=0.001$).

Table 8-14 Hierarchical GEE model of predictors of the change in BMI

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of BMI over the one year of follow-up from hierarchical GEE model

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Study time	0.22	0.18, 0.26	0.08	-0.18, 0.34	0.55
Community environment	Resident location					
	Wealthy districts	0.16	-0.19, 0.50	_	_	_
	Less wealthy districts	0.00				
	Safety of environment					
	Yes[2]	-0.52	-0.96, -0.08	-0.80	-1.27, -0.33	0.001
School environment	Amount of play equipment	-0.001	-0.02, 0.02	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	-0.07	-0.54, 0.40	_	_	_
	Highest	0.19	-0.26, 0.64	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.06	-0.36, 0.48	0.21	-0.21, 0.62	0.33
	Wealthiest	0.80	0.36, 1.24	0.94	0.49, 1.39	0.000
	Cognitive scores					
	Lowest	0.00		0.00		
	Middle	0.34	-0.10, 0.79	0.17	-0.26, 0.60	0.44
	Highest	0.47	0.03, 0.91	0.43	0.01, 0.85	0.04
	Emotional scores					
	Lowest	0.00				
	Middle	0.34	-0.10, 0.79	_	_	_
	Highest	0.47	0.03, 0.91	_	_	_
Family environment	Home good food environment scores					
	Lowest	0.00		0.00		
	Middle	-0.29	-0.72, 0.13	-0.55	-0.98, -0.12	0.012
	Highest	-0.58	-1.02, -0.15	-0.71	-1.13, -0.29	0.001
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.32	0.11, 0.95	0.55	0.14, 0.95	0.008
	Overweight	0.53	-0.20, 0.83	0.66	0.14, 1.19	0.013
	Parental BMI status					
	Neither parent overweight	0.00		0.00		
	Mother only overweight	0.06	-0.57, 0.70	0.39	-0.27, 1.06	0.246
	Father only overweight	0.51	0.07, 0.94	0.40	-0.01, 0.80	0.054
	Both parents overweight	1.42	0.82, 2.03	1.38	0.74, 2.02	0.000

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Father education level					
	Primary school	0.00		0.00		
	Secondary school	0.32	-0.30, 0.95	0.13	-0.49, 0.75	0.67
	High school	0.97	0.39, 1.56	0.67	0.07, 1.27	0.029
	College/ University	1.27	0.66, 1.89	0.83	0.16, 1.50	0.016
Child's behaviour	Duration of breast feeding (months)	-0.03	-0.05, -0.01	-0.04	-0.06, -0.02	0.001
	Duration of sleeping (hours)	-0.33	-0.59, -0.08	_	_	_
	Energy (kcal)					
	Lowest	0.00				
	Medium	0.07	-0.03, 0.16	_	_	_
	Highest	0.05	-0.06, 0.15	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	0.03	-0.07, 0.13	_	_	_
	Highest	0.04	-0.07, 0.15	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	0.02	-0.07, 0.11	_	_	_
	Highest	-0.01	-0.12, 0.10	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.0001	-0.10, 0.10	_	_	_
	Highest	0.05	-0.07, 0.18	_	_	_
	Sedentary time (hours)	-0.01	-0.04, 0.03	_	_	_
	TV viewing (hours)	0.05	-0.003, 0.11	_	_	_
	Vigorous activity hours	-0.04	-0.08, 0.002	_	_	_
Child's characteristics	Age (months)	0.04	0.03, 0.04	0.02	-0.02, 0.07	0.306
	Gender					
	Girls	0.00		0.00		
	Boys	0.84	0.48, 1.19	0.82	0.46, 1.17	0.000
	Birth weight (100 grams)	0.09	0.05, 0.13	0.06	0.03, 0.10	0.001
Interaction between gender and study time				0.15	0.06, 0.24	0.001

[1] *p-value for adjusted coefficients were calculated from the multivariate GEE analysis*
[2] *No is reference*
_ *Data were not available*

Similarly, the significant interaction between gender and the time period of the study was found in the combined gender models of determinants for changes in individual and the sum of skinfold thickness measurements, and the development of overweight and obesity. Therefore, the GEE models for each outcome of interest were performed separately for boys and girls. The following sections in part B present the gender specific models for each outcome of interest. The combined gender models for the outcomes of interest with a significant interaction term can be found in the Appendix 2 (Table 1 – Table 6). There were seven outcomes of interest including changes over time in BMI, triceps, subscapular, suprailiac skinfold thicknesses, the sum of skinfold thicknesses, and the development of overweight (including obesity) and obesity. The gender specific models for each of these outcomes are presented in turn. The findings of univariate analyses for each outcome are shown in the Appendix 3.

8.3.2.1 Risk factors for change in BMI

The relationship between environmental factors, individual characteristics, and the change in BMI in girls over the one year of follow up are shown in Table 8-15. At the community environment level, after adjustment for other variables in this level, parental perception of neighborhood safety was significantly negatively associated with the change in BMI over one year (coefficient: -0.59, 95% CI: -1.16, -0.01). The availability of a play ground, fast food and local fast food outlets and a game shop nearby, were not statistically significant.

The factors at the preschool environment level were not shown to have an effect on the BMI changes over the year after controlling for significant variables at the community level. The importance of the family environment factors for the change in BMI over one year included the emotional relationship and home good-food environment scores. Children with the medium and highest emotional support were more likely to have an increased BMI by 0.86 units (95% CI: 0.16, 1.57) and 0.91 units (95% CI: 0.22, 1.61) respectively, during the one year of follow-up. This association was not seen in the combined gender models, or for boys (Table 8-12, 8-14). There was a protective effect of a good home food environment on the change in BMI over one year for girls (coefficient: -1.23, 95% CI: -1.91, -0.55).

At the parental characteristic level, the maternal pre-pregnant overweight status was found to predict the changes in BMI in their offspring over time. Children born to overweight mothers had a significantly increased BMI during the year, compared with children who were born to underweight mothers, (coefficients: 0.77, 95% CI: 0.08, 1.46). The overweight status of parents assessed at the baseline, parental education levels and parental occupations were not related to the changes in BMI over time in girls.

Factors at the child's behaviour level including duration of sleep, dietary intake and physical activity, were all not significant in the multivariate analysis. Similarly, the duration of breast feeding was not significantly associated with the change in BMI in girls (coefficient: -0.01, 95% CI: -0.04, 0.01, p=0.349) whilst this relationship was seen for boys (Table 8-16). The only child characteristic that was statistically significant was birth weight, where each additional one hundred grams of birth weight predicted an increase of 0.06 units (95% CI: 0.03, 0.10) in BMI. Neither age in months, nor time, were significantly related to the development of BMI in girls over one year.

Table 8-15 Hierarchical GEE models of predictors of the change in BMI in girls

The adjusted coefficients and the 95% confidence intervals for predictors of the tracking of BMI in girls over the one year of follow-up from hierarchical GEE model

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Study time	0.22	0.18, 0.26	0.02	-0.04, 0.08	0.52
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.23	-0.20, 0.66	_	_	_
	Safety of environment					
	Yes[2]	-0.57	-1.15, 0.005	-0.59	-1.16, -0.01	0.045
School environment	Amount of play equipment	-0.003	-0.03, 0.03	_	_	_
	School food environment scores					
	Smallest	0.00				
	Medium	-0.61	-1.31, 0.09	_	_	_
	Highest	-0.45	-1.13, 0.22	_	_	_
Family environment	Cognitive scores					
	Lowest	0.00				
	Middle	0.89	0.24, 1.54	_	_	_
	Highest	1.13	0.48, 1.78	_	_	_
	Emotional scores					
	Lowest	0.00		0.00		
	Middle	0.42	-0.32, 1.15	0.86	0.16, 1.57	0.016
	Highest	0.80	0.06, 1.55	0.91	0.22, 1.61	0.010
	Home food environment scores					
	Lowest	0.00		0.00		
	Middle	-0.46	-0.97, 0.05	-0.26	-1.01, 0.49	0.493
	Highest	-0.69	-1.26, -0.11	-1.23	-1.91, -0.55	0.000
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.33	-0.31, 0.98	-0.02	-0.78, 0.73	0.953
	Overweight	0.68	0.18, 1.19	0.77	0.08, 1.46	0.028
	Parental BMI status					
	Neither parent overweight	0.00				
	Father only overweight	0.81	0.29, 1.34	_	_	_
	Mother only overweight	0.50	-0.26, 1.25	_	_	_
	Both parents overweight	1.66	0.83, 2.49	_	_	_
Child's behaviour	Duration of breast feeding (months)	-0.01	-0.04, 0.01	_	_	_
	Duration of sleeping (hours)	-0.38	-0.71, -0.05	_	_	_

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
Child's behaviour	Energy kcal					
	Lowest	0.00				
	Medium	0.07	-0.06, 0.22	_	_	_
	Highest	0.11	-0.02, 0.24	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	-0.08	-0.20, 0.05	_	_	_
	Highest	-0.10	-0.24, 0.03	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	-0.07	-0.19, 0.05	_	_	_
	Highest	-0.02	-0.15, 0.12	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.03	-0.09, 0.15	_	_	_
	Highest	0.05	-0.09, 0.19	_	_	_
	Sedentary activity (hours)	0.02	-0.02, 0.06	_	_	_
	TV viewing hours	0.10	0.02, 0.17	_	_	_
	Vigorous activity hours	0.001	-0.06, 0.06	_	_	_
Child's characteristics	Age (months)	0.025	0.01, 0.03	0.02	-0.04, 0.08	0.524
	Birth weight (100 grams)	0.07	0.02, 0.12	0.06	0.03, 0.10	0.001

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ Data were not available

Table 8-16 shows the multivariate relationships based on the hierarchical conceptual framework of determinants for change in BMI in boys aged four to five years over the one year period. At the community level, the significant factors for boys and girls were similar. Living in a safe neighborhood, as perceived by parents, was found to be associated with a reduced BMI of 0.80 units (95% CI: -1.53, -0.08) over the one year of follow-up compared with their counterparts, whose parents perceived that their neighborhood was not safe. Place of residence, availability of play grounds nearby, accessibility to video/computer game shops, Western and local fast food outlets nearby, were not significantly related to the changes in BMI in boys over the year of follow-up. In the multivariate analysis there were no effects of preschool environment factors on the development of BMI in boys over the follow-up period.

At the family environment level, the associations between household wealth index and cognitive scores remained significant after adjusting for other factors from more distal levels. Children from the wealthiest households were more likely to have an increased BMI by 0.81 units (95% CI: 0.17, 1.46) during the year of follow-up compared with those from the lowest household wealth group. Similarly, children with the highest scores for cognitive encouragement from parents for primary preschool preparation, reading stories and offering any kind of outing to the child, were more likely to have an increased BMI by 1.06 units (95% CI: 0.42, 1.69) during the year of follow-up compared with children in the group with the lowest cognitive scores. Having both parents overweight, assessed at baseline, was strongly predictive of an increase in BMI in children over the year of follow up (coefficient: 1.18, 95% CI: 0.21, 2.16). There was a statistically significant relationship between higher paternal education such as high school and college or university attainment, with the development of BMI in their sons over time (coefficients: 0.67, 95% CI: 0.07, 1.27 and 0.83, 95% CI: 0.16, 1.50 respectively).

At the child behavior level, the only protective effect was from longer duration of breast feeding that remained significant in the multivariate model, with a decrease in BMI by -0.05 unit (95% CI: -0.08, -0.02) over the time of follow-up. As with girls, boys with an additional one hundred grams of birth weight were more likely to gain BMI by 0.07 units (95% CI: 0.001, 0.12) after one year.

Table 8-16 Hierarchical GEE models of predictors of the changes in BMI in boys

The adjusted coefficients and the 95% confidence intervals for predictors of the tracking of BMI in boys over the one year of follow-up from hierarchical GEE model

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Study time	0.22	0.18, 0.26	0.04	-0.33, 0.41	0.83
Community environment	Resident location					
	Wealthy districts	0.09	-0.44, 0.62	_	_	_
	Less wealthy districts	0.00				
	Safety of environment					
	Yes[2]	-0.50	-1.17, 0.16	-0.80	-1.53, -0.08	0.03
School environment	Amount of play equipment	-0.003	-0.03, 0.03	_	_	_
	School food environment scores					
	Smallest	0.00				
	Medium	-0.61	-1.31, 0.09	_	_	_
	Highest	-0.45	-1.13, 0.22	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.10	-0.56, 0.77	0.15	-0.50, 0.81	0.643
	Wealthiest	0.74	0.08, 1.40	0.81	0.17, 1.46	0.013
	Cognitive scores					
	Lowest	0.00		0.00		
	Middle	0.89	0.24, 1.54	0.61	-0.02, 1.24	0.057
	Highest	1.13	0.48, 1.78	1.06	0.42, 1.69	0.001
	Emotional scores					
	Lowest	0.00				
	Middle	0.12	-0.95, 1.19	_	_	_
	Highest	0.70	-0.39, 1.79	_	_	_
	Home food environment scores					
	Lowest	0.00				
	Middle	-0.19	-0.86, 0.47	_	_	_
	Highest	-0.45	-1.09, 0.19	_	_	_
Parental characteristics	Parental BMI status					
	Neither parent overweight	0.00		0.00		
	Father only overweight	0.33	-0.34, 1.01	0.26	-0.38, 0.90	0.420
	Mother only overweight	-0.20	-1.27, 0.86	0.02	-1.01, 1.04	0.977
	Both parents overweight	1.33	0.49, 2.18	1.18	0.21, 2.16	0.018
	Father's education level					
	Primary school	0.00		0.00		
	Secondary school	0.87	-0.15, 1.88	0.36	-0.63, 1.34	0.478
	High school	1.67	0.70, 2.64	1.13	0.11, 2.14	0.03
	College/ University	1.62	0.61, 2.63	1.10	0.03, 2.17	0.043

Levels	Factors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
Child's behaviour	Duration of breast feeding (months)	-0.04	-0.07, -0.005	-0.05	-0.08, -0.02	0.004
	Duration of sleeping (hours)	-0.32	-0.68, 0.05			
	Energy (kcal)					
	Lowest	0.00				
	Medium	-0.002	-0.14, 0.14	_	_	_
	Highest	-0.02	-0.17, 0.13	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	0.15	-0.01, 0.31	_	_	_
	Highest	0.19	0.02, 0.37	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	0.01	-0.18, 0.19	_	_	_
	Highest	0.12	-0.02, 0.27	_	_	_
	Sedentary activity (hours)	-0.03	-0.08, 0.02	_	_	_
	TV viewing (hours)	0.01	-0.08, 0.09	_	_	_
	Vigorous activity (hours)	-0.09	-0.16, -0.02	_	_	_
Child's characteristics	Age (months)	0.049	0.04, 0.06	0.04	-0.02, 0.11	0.188
	Birth weight (100 grams)	0.09	0.04, 0.15	0.07	0.001, 0.13	0.048

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ *Data were not available*

8.3.2.2 Risk factors for change in sum of skinfold thicknesses

The hierarchical relationship between the predictors and the change in the sum of triceps, subscapular and suprailiac skinfold thicknesses (SSFs) in girls aged four to five years over the time period of the study are shown in Table 8-17. At the community level, the importance of the safety of the neighborhood as perceived by parents, was confirmed in the model. Children whose parents believed that their neighborhood was safe for their child to play outdoors, had a significant decrease in the SSFs by 2.71 mm (95% CI: -5.07, -0.35) over the year of follow-up.

With regard to the preschool environment factors, there was a dose response between preschool food environment with the change in SSFs over the year of follow-up (coefficients: medium score: 3.22, 95% CI: 0.02, 6.42, highest score: 4.19, 95% CI: 1.25, 7.13 respectively). The influence of the school food environment on BMI changes was not found for boys, or for the combined gender model.

After adjustment for factors at the community and preschool levels, the role of the family environment was characterized by an association between emotional and home food environments, and the change in SSFs over time. There were significant increases in the SSFs over time with the higher score of the cognitive emotional support from the parents (coefficients: medium score: 4.11, 95% CI: 0.25, 7.98, highest score: 5.74, 95% CI: 1.58, 9.91). Again, this association was determined for girls but not for boys or the combined gender model. In contrast, there was a negative relationship between the highest score of good home food environment with the change in the SSFs over the one year of study (coefficient: -5.12, 95% CI: -8.87, -1.37). This finding is similar to that for boys (Table 8-18).

At the parental characteristic level, only paternal employment was statistically significant after adjustment for other factors from community, preschool and family environments. Children whose fathers worked as traders and government officers had a significant increase in the SSFs over time compared with those whose fathers worked as laborers or street and home traders (coefficients: 4.26, 95% CI: 0.12, 8.39; 6.20, 95% 0.98, 11.42 respectively). No child behaviour factors, including dietary intake, physical activity, and sleep patterns, were significantly associated with SSFs over time. Longer duration of breast feeding appeared to have an impact on SSFs changes in boys compared with girls, as an insignificant finding was seen for girls (coefficient: -0.10, 95% CI: -0.25, 0.05, p=0.205). Also, there was no significant association between factors at the child characteristic level with change in SSFs over the time period.

Table 8-17 Hierarchical GEE model of predictors for the change in SSFs in girls

The adjusted coefficients and the 95% confidence intervals for predictors of the change in SSFs in girls over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Study time	2.23	1.84, 2.62	0.36	-1.67, 2.39	0.728
Community environment	Resident location					
	Wealthy districts	1.31	-0.99, 3.61	_	_	_
	Less wealthy districts	0.00				
	Safety of environment					
	Yes[2]	-2.08	-5.09, 0.93	-2.71	-5.07, -0.35	0.025
School environment	Amount of play equipment	-0.01	-0.13, 0.10	_	_	_
	School food environment scores					
	Smallest	0.00		0.00		
	Medium	3.08	-0.08, 6.24	3.22	0.02, 6.42	0.048
	Largest	4.19	1.16, 7.22	4.19	1.25, 7.13	0.005
Family environment	Cognitive scores					
	Lowest	0.00				
	Medium	4.28	-0.10, 8.66	_	_	_
	Highest	4.20	0.02, 8.37	_	_	_
	Emotional scores					
	Lowest	0.00		0.00		
	Medium	1.73	-1.78, 5.23	4.11	0.25, 7.98	0.037
	Highest	4.10	0.49, 7.72	5.74	1.58, 9.91	0.007
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-2.02	-4.89, 0.86	-1.81	-6.15, 2.53	0.413
	Highest	-3.00	-5.89, -0.10	-5.12	-8.87, -1.37	0.007
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00		2.39	-7.56, 12.35	0.638
	Normal	-0.22	-3.41, 2.98	4.26	0.12, 8.39	0.044
	Overweight	2.95	0.23, 5.69	6.20	0.98, 11.42	0.020
	Parental BMI status					
	Neither parent overweight	0.00				
	Mother only overweight	1.85	-2.33, 6.02	_	_	_
	Father only overweight	2.94	0.06, 5.81	_	_	_
	Both parents overweight	6.49	2.26, 10.72	_	_	_

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
Parental characteristics	Paternal occupations					
	Labourer/ Street or home trader	0.00				
	Home maker/ Others	2.07	-2.79, 6.92	6.99	-3.46, 17.45	0.190
	Small business/ Skilled workers	-0.86	-9.07, 7.34	2.39	-7.56, 12.35	0.638
	Traders	3.97	0.77, 7.16	4.26	0.12, 8.39	0.044
	Government officers	5.61	2.17, 9.05	6.20	0.98, 11.42	0.020
	Teacher/ Professionals	4.84	1.58, 8.11	1.28	-3.75, 6.31	0.617
Child's behaviour	Duration of breast feeding (months)	-0.10	-0.25, 0.05	_	_	_
	Duration of sleeping (hours)	-1.28	-2.67, 0.10	_	_	_
	Energy (kcal)					
	Lowest	0.00				
	Medium	0.15	-0.89, 1.19	_	_	_
	Highest	0.58	-0.40, 1.57	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	-0.74	-1.69, 0.21	_	_	_
	Highest	-0.83	-1.92, 0.27	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	-0.14	-1.05, 0.76	_	_	_
	Highest	-0.13	-1.14, 0.88	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.32	-0.56, 1.19	_	_	_
	Highest	0.41	-0.66, 1.48	_	_	_
	Vigorous activity hours	-0.38	-0.77, 0.01	_	_	_
	Sedentary activity (hours)	0.18	-0.13, 0.49	_	_	_
	TV viewing (hours)	0.76	0.22, 1.30	_	_	_
Child's characteristics	Age (months)	0.38	0.32, 0.45	0.32	-0.02, 0.66	0.064
	Birth weight (100 grams)	0.06	-0.23, 0.35	_	_	_

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ Data were not available

Table 8-18 presents the adjusted coefficients of the predictors for the change in SSFs in boys over the one year follow-up from a hierarchical GEE model. Among the community level factors, again there was a protective effect of the parental perception of the safety of the neighborhood on the change in SSFs (coefficient: -4.16, 95% CI: -8.28, -0.05). The preschool environment factors did not have any influence on the change in SSFs over time.

In terms of the influences of the family environment on SSFs changes, there was a significant relationship between the household wealth index and the change in the SSFs over the year. Children from the wealthiest households were observed to experience an increase in the SSFs by 3.96 mm (95% CI: 0.14, 7.78) compared with those from the poorest families. A significant increase in the SSFs over time was also seen for those who had the highest score of cognitive encouragement from the parents (coefficient: 4.99, 95% CI: 1.44, 4.50). Thus, the gender difference was found in examining the household economic status and the quality of the home environment on the child's development on SSFs changes. Insignificant relationships between the household economic status or cognitive stimulant with SSFs changes were seen in girls whilst the emotional relationship with parents had impact on SSFs change in girls rather than boys and in the combined gender model. However, the negative relationship between the highest score of good home food environment with the change in the SSFs in boys over the one year of the study (coefficient: -4.54, 95% CI: -8.09, -0.99), is similar to that observed in girls.

Maternal pre-pregnant overweight, parental overweight assessed at the baseline, and paternal education level were observed to significantly associate with SSFs changes in children in the combined gender model (Table 1-Appendix 2). However, these factors did not predict the change in SSFs over time in gender specific models, except for a significant association between paternal employment in professional jobs and SSFs changes in girls. There was a protective effect of longer duration of breast feeding with the development of SSFs over the one year period (coefficient: -0.22, 95% CI: -0.40, -0.05). Similarly as seen with BMI changes, breast feeding was only shown to have significance on SSFs changes in boys compared with girls. Children who consumed more protein were observed to be statistically significantly associated with higher SSFs over time (coefficient: 1.17, 95% CI: 0.10, 2.23). Again, this effect was not seen in girls as in boys and in the combined gender models.

At the level of child characteristics, there was a positive relationship between age and the change in SSFs over the one year of follow-up (coefficient: 0.45, 95% CI: 0.19, 0.70). Furthermore, each additional one hundred grams of birth weight significantly predicted a higher SSFs at the end of follow-up (coefficient: 0.40, 95% CI: 0.05, 0.75).

Table 8-18 Hierarchical GEE model of predictors for the changes in SSFs in boys

The adjusted coefficients and the 95% confidence intervals for predictors of the tracking of SSFs in boys over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
	Study time	2.53	2.29, 2.79	0.05	-1.32, 1.42	0.95
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	1.74	-1.10, 4.57			
	Safety of environment					
	Yes[2]	-3.47	-7.11, 0.18	-4.16	-8.28, -0.05	0.047
School environment	Amount of play equipment	0.04	-0.12, 0.19	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	-1.73	-5.31, 1.86	_	_	_
	Highest	-3.04	-7.06, 0.97	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.36	-3.22, 3.95	0.64	-2.86, 4.15	0.72
	Wealthiest	3.1	-0.53, 6.72	3.96	0.14, 7.78	0.042
	Cognitive score					
	Lowest	0.00		0.00		
	Medium	3.91	0.42, 7.39	3.96	-0.51, 6.14	0.097
	Highest	5.81	2.19, 9.43	4.99	1.44, 8.54	0.006

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value[1]
Family environment	Emotional scores					
	Lowest	0.00				
	Medium	-0.36	-6.14, 5.42	_	_	_
	Highest	2.25	-3.82, 8.33	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-1.67	-5.28, 1.92	-2.63	-6.37, 1.12	0.169
	Highest	-3.25	-6.82, 0.32	-4.54	-8.09, -0.99	0.012
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.18	-3.86, 4.23	_	_	_
	Overweight	1.90	-1.59, 5.39	_	_	_
	Parental BMI status					
	Neither parent overweight	0.00				
	Mother only overweight	-2.11	-7.81, 3.59	_	_	_
	Father only overweight	2.41	-1.45, 6.27	_	_	_
	Both parents overweight	4.26	-0.86, 9.39	_	_	_
Child's behaviour	Duration of breast feeding (months)	-0.24	-0.42, -0.06	-0.22	-0.40, -0.05	0.012
	Duration of sleeping (hours)	-1.54	-3.72, 0.65			
	Energy kcal					
	Lowest	0.00				
	Medium	0.16	-0.89, 1.21	_	_	_
	Highest	0.29	-0.74, 1.32	_	_	_
	Protein (g)					
	Lowest	0.00		0.00		
	Medium	0.34	-0.91, 1.59	0.57	-0.45, 1.59	0.273
	Highest	0.82	-0.42, 2.06	1.17	0.10, 2.23	0.032
	Fat (g)					
	Lowest	0.00				
	Medium	0.47	-0.63, 1.56	_	_	_
	Highest	-0.41	-1.80, 0.99	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.21	-1.12, 1.53	_	_	_
	Highest	0.42	-0.64, 1.48	_	_	_
	Sedentary activity (hours)	0.01	-0.37, 0.39	_	_	_
	TV viewing (hours)	0.33	-0.34, 0.99	_	_	_
	Vigorous activity (hours)	-0.88	-1.37, -0.40	_	_	_
Child's characteristics	Age (months)	0.49	0.42, 0.56	0.45	0.19, 0.70	0.001
	Birth weight (100 grams)	0.34	0.01, 0.67	0.4	0.05, 0.75	0.025

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ Data were not available

8.3.2.3 Risk factors for change in individual skinfold thickness

This section presents the similarities and differences between determinants predicting the change in individual skinfold thickness at triceps (TSF), subscapular (SSSF), suprailiac (SISF) sites in comparison with those associated with the change in the sum of skinfold thicknesses in children aged four to five years in both genders over the one year of follow-up. Details of the models for each individual skinfold thickness measurement can be found in Appendix 4.

At the neighborhood environment level, the safety of the environment as perceived by parents, significantly influenced the development of each individual skinfold thickness over time in boys, similar to that reported for the sum of skinfold thicknesses. Boys whose parents believed that their neighborhood environment was safe, had a statistically significant reduction in TSF by 1.33 mm (95% CI: -2.58, -0.08), in SSSF by 1.06 mm 95% CI:-1.97, -0.16), in SISF by 0.72 mm (95% CI: 0.02, 1.41) over the one year period. However, parental perception on the safety of the neighborhood did not relate to the changes in each individual skinfold thickness over time in girls, although this association was found for the sum of skinfold thicknesses. The availability of a play ground nearby, resident location in a wealthy or less wealthy district, accessibility of Western and local fast food outlets and a games shop in the neighborhood area, were not significantly associated with change in individual or the sum of skinfold thicknesses. With regard to the role of the economic level of the community on changes in each individual and the sum of skinfold thickness, boys from wealthy districts demonstrated a significant gain in SISF over one year (coefficient: 0.72, 95% CI: 0.02, 1.41).

The school environment factors of the amount of play equipment and school food environment, had significant impacts on changes in each of the individual and the sum of skinfold thicknesses.

The number of items of play equipment in the preschool was shown to protect against an increase in TSF over time in girls and SSSF in boys over the one year of follow-up, although the p-value for change in TSF in girls was only of borderline significance (p=0.051). However, this protective factor was not seen with other individual and the sum of skinfold thicknesses in children of both genders. Also at this level, the preschool food environment was observed to predict change in the sum of skinfold thicknesses in girls, however, no association was observed for individual skinfold thicknesses in children of both genders.

The influence of family environment factors on changes in individual skinfold thickness was similar to that for the sum of skinfold thicknesses. Children from wealthy households were shown to have significant increases in all individual skinfold thickness measurements as well as the sum of skinfold thicknesses; however, this association was more prominent in boys than in girls. Boys who were from the wealthiest households demonstrated a significant increase in TSF of 1.61 mm (95% CI: 0.44, 2.78), in SSSF of 1.40 mm (95% CI: 0.088, 2.73) and in SISF of 1.45 mm (95% CI: 0.01, 2.89) over the one year of follow-up compared with those from the poorest households. In both genders, there was a similar impact of the quality of home environment factors on changes in individual skinfold thickness over time as was seen for change in the sum of skinfold thicknesses.

Higher emotional stimulation was found to predict positive changes in TSF (coefficient: 1.48, 95% CI: 0.24, 2.71) and in SISF (coefficients: medium score: 1.86, 95% CI: 0.55, 2.65; highest score: 2.27, 95% CI: 0.59, 3.95) in girls. Whereas boys who received higher stimulation of cognitive development from the parents, also experienced an increase in TSF (coefficients: 1.56, 95% CI: 0.44, 2.66) and in SISF (coefficients: medium score: 1.46, 95% CI: 0.17, 2.75; highest score: 2.15, 95% CI: 0.81, 3.49 respectively), as well as in SSSF (coefficient: 1.60, 95% CI: 0.27, 2.93) during the one year of follow-up. Thus, as reported for the changes in BMI and SSFs, there was a different impact from the quality of the home environment in terms of cognitive stimulant and emotional relationship on changes in individual skinfold thickness. Higher cognitive stimulant scores were significantly associated with an increased adiposity over time in boys while higher emotional scores predicted the changes in adiposity over time in girls, although only a higher cognitive stimulant score was found to significantly relate to the changes in BMI, individual and sum of skinfold thickness in the combined gender models (Table 8-12, Table 1 - Table 6, Appendix 2).

There were gender differences in the associations between the good home-food environment and changes in TSF and SSSF over time. Boys from the households with the higher good home-food environment scores had a decrease in TSF (coefficients: medium score: -1.58, 95% CI: -2.69, -0.64; highest score: -1.24, 95% CI: 2.42, -0.07), in SSSF (1.89, 95% CI: -3.11, -0.67) and in SISF (1.41, 95% CI -2.75, -0.07) over time, whereas, this association was seen only for change in SISF in girls (1.81, 95% CI: -3.34, -0.27).

Amongst the parental characteristics, parental employment and maternal pre-pregnant overweight status were found to have an impact on changes in individual skinfold thickness in girls but not boys. Girls, whose parents were employed in professional jobs such as traders or government officers, had significant increases in TSF, SSSF and SISF. The findings were similar to those observed for change in sum of skinfold thicknesss over time. Parental overweight status assessed at the baseline was not associated with changes in individual or the sum of skinfold thicknesses over time in children of both genders. However, girls who were born to overweight mothers had an increase in SSSF over the follow-up period compared with those who were born to underweight mothers (coefficient: 1.58, 95% CI: 0.18, 2.98).

Considering the role of the child behavior factors, breast feeding and protein consumption were significantly associated with changes in individual skinfold thickness, and these results differed from those for the sum of skinfold thicknesses. For each additional month of breast feeding, children had a significant decrease in TSF, SSSF, and SISF over the one year period. Nevertheless, this protective effect appeared to be stronger in boys than in girls. Reductions over time in TSF (coefficient: -0.08, 95% CI: -0.14, -0.02), SSSF (coefficient: -0.09, -0.15, -0.03), and SISF (coefficient: -0.07, 95% CI: -0.14, -0.01) were found for boys while this association was only seen for change in SISF for girls (coefficient: -0.07, 95% CI: -0.11, -0.02). This is similar to findings for change in the sum of skinfold thicknesses. There were few significant relationships between nutrient intake and change in individual skinfold thickness. Higher protein consumption was predictive of change in SSSF only in boys (coefficient: 0.46, 95% CI: 0.12, 0.81) which was similar to the findings for change in sum of skinfold thickness. There was no association with changes in TSF and SISF in children of both genders. Physical activity level and hours of sleep at night were not significantly related to change in individual or sum of skinfold thicknesses.

Among the child characteristics, for each additional month in age, boys demonstrated a significant increase in TSF (coefficient: 0.17, 95% CI: 0.05, 0.28), SSSF (coefficient: 0.18 mm, 95% CI: 0.05, 0.31), and SISF (coefficient: 0.23, 95% CI: 0.08, 0.38). This linear relationship was observed only for change in SISF over time in girls. There was a positive relationship between high birth weight and change in TSF in boys that is similar to that observed for change in sum of skinfold thicknesses. Each additional one hundred grams in birth weight was significantly related to an increase in TSF by 0.13 mm (95% CI: 0.02, 0.23).

8.3.2.4 Risk factors for overweight (including obesity)

The inter-relationship of various factors with the development of overweight in girls aged four to five years over the one year of follow-up is shown in Table 8-19. At the community level, there were no factors that were statistically significant. Similarly, the school environment factors of preschool yard size, play equipment and school food environment did not influence the development of overweight in children.

When the factors at family environment level were added to the model, a higher risk of being overweight was significantly associated with the highest level of household wealth index (RR: 1.78, 95% CI: 1.24, 2.56). There was a dose-response relationship between good home-food scores with the relative risk of developing overweight for girls. Those girls from homes with the middle or highest good home-food scores were less likely to be overweight after one year of follow-up (RR: 0.71, 95% CI: 0.51, 0.99 and RR 0.65, 95% CI: 0.46, 0.93 respectively) compared with those from the lowest good home-food scores group.

At the parental characteristic level, only parental overweight status was statistically significant. Children whose parents were both overweight at baseline, were at higher risk of being overweight (RR: 1.79, 95% CI: 1.22, 2.62). In addition, paternal rather than maternal overweight was observed to elevate the risk of their daughter developing overweight during the year of study (RR: 1.55, 95% CI: 1.12, 2.15).

There was a statistically significantly higher risk of being overweight for those children who consumed more carbohydrate in their diet (RRs: medium group: 1.18, 95% CI: 1.03, 1.35; highest group: 1.19, 95% CI: 1.01, 1.39). Children who spent more time in vigorous activity were at lower risk of being overweight after the one year of follow-up. Each additional hour of vigorous activity was significantly associated with a ten percent decrease in the risk of developing overweight over time (RR: 0.90, 95% CI: 0.84, 0.96). In contrast, each additional hour spent viewing TV was shown to elevate the risk of becoming overweight over time (RR: 1.12, 95% CI: 1.03, 1.21).

The child characteristics including age, birth weight, and maternal weight gain in pregnancy, gestational diabetes, and birth order, were not significantly associated with the relative risk of being overweight in girls over the one year of follow-up.

Table 8-19 Hierarchical GEE models of predictors for the development of overweight in girls

The adjusted relative risk and the 95% confidence intervals of predictors for the development of overweight in girls over the one year of follow-up

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
	Study time	1.11	1.07, 1.16	1.05	0.83, 1.32	0.689
Community environment	Resident location					
	Less wealthy districts	1.00				
	Wealthy districts	1.25	0.96, 1.63			
	Safety of environment					
	Yes[2]	0.91	0.66, 1.26	_	_	_
School environment	Amount of play equipment	1.002	0.99, 1.02	_	_	_
	School food environment scores					
	Lowest	1.00				
	Medium	1.28	0.88, 1.85	_	_	_
	Highest	1.30	0.97, 1.91	_	_	_
Family environment	Wealth index					
	Poorest	1.00		1.00		
	Medium	1.22	0.84, 1.78	1.21	0.83, 1.78	0.325
	Wealthiest	1.78	1.25, 2.53	1.78	1.24, 2.56	0.002
	Cognitive score					
	Lowest	1.00				
	Medium	1.00	0.72, 1.39	_	_	_
	Highest	0.94	0.66, 1.34	_	_	_
	Emotional scores					
	Lowest	1.00				
	Medium	1.08	0.60, 1.95	_	_	_
	Highest	1.49	0.89, 2.48	_	_	_
Family environment	Home food environment scores					
	Lowest	1.00		1.00		
	Medium	0.76	0.55, 1.06	0.65	0.46, 0.93	0.019
	Highest	0.67	0.47, 0.96	0.71	0.51, 0.99	0.047
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	1.00				
	Normal	1.23	0.81, 1.87	_	_	_
	Overweight	1.43	1.01, 2.03	_	_	_
	Parental BMI status					
	Neither parent overweight	1.00		1.00		
	Mother only overweight	0.93	0.64, 1.35	1.21	0.66, 2.19	0.539
	Father only overweight	1.31	1.06, 1.61	1.55	1.12, 2.15	0.008
	Both parents overweight	1.84	1.47, 2.30	1.79	1.22, 2.62	0.003

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
Child's behaviour	Duration of breast feeding (months)	1.00	0.98, 1.01	_	_	_
	Birth weight (100 grams)	0.06	-0.23, 0.35			
	Energy (kcal)					
	Lowest	1.00				
	Medium	1.04	0.91, 1.19	_	_	_
	Highest	1.08	0.94, 1.25	_	_	_
	Protein (g)					
	Lowest	1.00				
	Medium	0.88	0.76, 1.03	_	_	_
	Highest	0.88	0.76, 1.02	_	_	_
	Fat (g)					
	Lowest	1.00		_	_	_
	Medium	0.89	0.77, 1.03	_	_	_
	Highest	0.96	0.86, 1.08	_	_	_
	Carbohydrate (g)					
	Lowest	1.00		1.00		
	Medium	1.14	1.003, 1.28	1.18	1.03, 1.35	0.017
	Highest	1.16	1.00, 1.36	1.19	1.01, 1.39	0.037
	Sedentary time (hours)	1.03	0.99, 1.07	_	_	_
	TV viewing (hours)	1.12	1.04, 1.21	1.12	1.03, 1.21	0.006
	Vigorous activity (hours)	0.91	0.85, 0.97	0.90	0.84, 0.96	0.001
Child's characteristics	Age (months)	1.02	1.01, 1.03	1.01	0.97, 1.05	0.646
	Birth weight (100 grams)	1.03	1.00, 1.07	1.05	0.83, 1.32	0.689

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ Data were not available

Table 8-20 shows the adjusted relative risks of determinants for the development of overweight in boys aged four to five years over the one year of follow-up. As reported in the girls, there were no associations found between influences of the community and preschool environments with overweight in boys.

At the family environment level, household wealth status and cognitive stimulation from parents were associated with an increased risk of overweight in boys. Children from the wealthiest families were at higher risk of being overweight at the end of the follow-up compared with those from the poorest families (RR: 1.34, 95% CI: 1.03, 1.76). There was a positive relationship between the highest cognitive scores and the risk of developing overweight in boys over time (RR: 1.45, 95% CI: 1.08, 1.93). Again, this relationship was not found in girls. This was also different from that observed in the combined gender model where the higher emotional score was related to an increased risk of being overweight (Table 5-Appendix 2).

Examining the role of the parental characteristic level, only parental overweight status remained significant in the multivariate analysis. If both parents were overweight, the risk of their son being overweight significantly increased (RR: 1.56, 95% CI: 1.15, 2.12).

Among the child behavior factors, children who spent more time in vigorous activity in a day had an 8% decrease in the risk of developing overweight (95% CI: 0.86, 0.98). However, there was no statistically significant relationship between viewing TV and the risk of developing overweight in boys, whilst it was seen in girls and in the combined gender models.

After controlling for other factors, nutrient intake of total energy, energy adjusted macronutrients, and the percentage of energy from each of the macronutrients, were not significantly associated with the risk of developing overweight over the one year of follow-up. There was no significant association between the child characteristics and the risk of being overweight over the one year of follow-up.

Table 8-20 Hierarchical GEE models of predictors for the development of overweight in boys

The adjusted relative risk and the 95% confidence intervals of predictors for the development of overweight in boys aged 4 to 5 years over the one year of period

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
	Study time	1.12	1.07, 1.18	1.06	0.89, 1.28	0.500
Community environment	Resident location					
	Less wealthy districts	1.00				
	Wealthy districts	0.98	0.79, 1.23	_	_	_
	Safety of environment					
	Yes[2]	0.93	0.71, 1.22	_	_	_
School environment	Amount of play equipment	1.002	0.99, 1.02	_	_	_
	School food environment scores					
	Lowest	1.00				
	Medium	0.85	0.62, 1.18	_	_	_
	Highest	0.96	0.72, 1.27	_	_	_
Family environment	Wealth index					
	Poorest	1.00		1.00		
	Medium	1.02	0.74, 1.41	1.04	0.77, 1.42	0.785
	Wealthiest	1.33	1.01, 1.75	1.34	1.03, 1.76	0.031
	Cognitive scores					
	Lowest	1.00		1.00		
	Medium	1.3	0.96, 1.78	1.23	0.91, 1.68	0.178
	Highest	1.46	1.09, 1.97	1.45	1.08, 1.93	0.013
	Emotional scores					
	Lowest	1.00				
	Medium	1.22	0.73, 2.03	_	_	_
	Highest	1.49	0.92, 2.40	_	_	_
	Home food scores					
	Lowest	1.00				
	Medium	1.02	0.78, 1.33	_	_	_
	Highest	0.91	0.68, 1.23	_	_	_
Parental characteristics	Maternal pre-pregnant BMI status			0.84	0.49, 1.41	0.503
	Underweight	1.00		0.84	0.49, 1.41	0.503
	Normal	1.12	0.79, 1.58	1.08	0.84, 1.41	0.541
	Overweight	1.13	0.86, 1.50	1.56	1.15, 2.12	0.004
	Parental BMI status					
	Neither parent overweight	1.00		1.00		
	Mother only overweight	0.82	0.47, 1.43	0.84	0.49, 1.41	0.503
	Father only overweight	1.15	0.87, 1.51	1.08	0.84, 1.41	0.541
	Both parents overweight	1.61	1.21, 2.14	1.56	1.15, 2.12	0.004

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value
Child's behaviour	Duration of breast feeding (months)	0.98	0.97, 0.99	_	_	_
	Duration of sleeping (hours)	0.91	0.77, 1.06			
	Energy (kcal)					
	Lowest	1.00				
	Medium	1.03	0.93, 1.14	_	_	_
	Highest	1.06	0.93, 1.21	_	_	_
	Protein (g)					
	Lowest	1.00				
	Medium	1.03	0.92, 1.16	_	_	_
	Highest	1.05	0.96, 1.16	_	_	_
	Fat (g)					
	Lowest	1.00				
	Medium	0.96	0.85, 1.08	_	_	_
	Highest	0.93	0.82, 1.05	_	_	_
	Carbohydrate (g)					
	Lowest	1.00				
	Medium	0.97	0.87, 1.08	_	_	_
	Highest	1.00	0.89, 1.12	_	_	_
	Sedentary time (hours)	1.01	0.98, 1.04	_	_	_
	TV viewing (hours)	1.01	0.96, 1.06	_	_	_
	Vigorous activity (hours)	0.90	0.84, 0.95	0.92	0.86, 0.98	0.007
Child characteristics	Age (months)	1.02	1.01, 1.03	1.00	0.98, 1.04	0.542
	Birth weight (100 grams)	1.02	1.01, 1.06	_	_	_

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ *Data were not available*

8.3.2.5 Risk factors associated with the development of obesity

Table 8-21 shows the results of multivariate analysis of the predictors for the development of obesity over the one year follow-up in girls using the hierarchical GEE modeling. At the community level, children who lived in a safe neighborhood (as perceived by the parents) were at a lower risk of being obese over the year of follow-up (RR: 0.51, 95% CI: 0.46, 0.94) compared with those whose parents believed their neighborhoods were unsafe.

Of the preschool environment factors, only the food environment significantly impacted on the development of obesity in girls. Children whose preschool food environment score was categorised in the highest group, were 3.57 times (95% CI: 1.58, 8.10) more likely to be obese compared with those with the lowest preschool food scores. This impact was not found in boys or the combined gender model (Table 6-Appendix 2).

The influence of the family environment on the development of obesity highlighted the importance of the household wealth index. Children from the wealthiest households were at higher risk of developing obesity compared with those from the poorest families (RR: 2.59, 95% CI: 1.17, 5.73). However, the role of the household wealth status only had significance on obesity development in girls, as this association was not seen for boys.

At the parental characteristics level, higher relative risks of becoming obese over time were seen for paternal overweight (RR: 2.52, 95% CI: 1.19, 5.35) and both parents being overweight (RR: 2.91, 95% CI: 1.31, 6.48). Considering the child behaviour characteristics, the only significant factor was breast feeding. For each additional month of breast feeding, children were 0.96 times (95% CI: 0.92, 0.99) less likely to develop obesity over the one year period of follow-up.

The age, birth weight, maternal weight gain, gestational diabetes, premature birth, and birth order were not statistically significantly associated with the development of obesity over time in girls.

Table 8-21 Hierarchical GEE models of predictors for the development of obesity in girls

The adjusted relative risk and the 95% confidence intervals of predictors for the development of obesity in girls over the one year of period from the GEE model

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
	Study time	1.04	0.97, 1.11	0.68	0.41, 1.12	0.127
Community environment	Resident location					
	Wealthy districts	1.29	0.75, 2.23			
	Less wealthy districts	0.00				
	Safety of environment					
	Yes[2]	0.52	0.28, 0.95	0.51	0.28, 0.94	0.029
School environment	Amount of play equipment	0.99	0.96, 1.01	_	_	_
	School food environment scores					
	Lowest	1.00		1.00		
	Medium	1.99	0.81, 4.84	1.6	0.57, 4.48	0.367
	Highest	4.15	2.08, 8.28	3.57	1.58, 8.10	0.002
Family environment	Wealth index					
	Poorest	1.00		1.00		
	Medium	1.33	0.61, 2.90	1.71	0.76, 3.87	0.196
	Wealthiest	1.86	0.92, 3.79	2.59	1.17, 5.73	0.018
	Cognitive scores					
	Lowest	0.00				
	Medium	0.80	0.41, 1.57	_	_	_
	Highest	0.73	0.36, 1.48	_	_	_
	Emotional scores					
	Lowest	0.00				
	Medium	1.68	0.47, 5.98	_	_	_
	Highest	1.83	0.49, 6.89	_	_	_
	Home food environment scores					
	Lowest	0.00				
	Medium	0.54	0.26, 1.13	_	_	_
	Highest	0.61	0.31, 1.20	_	_	_
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	1.85	0.82, 4.16	_	_	_
	Overweight	2.08	0.85, 5.09	_	_	_
	Parental BMI status	4.32	2.05, 9.14	2.91	1.31, 6.48	0.009
	Neither parent overweight	1.00		1.00		
	Mother only overweight	2.32	1.09, 4.94	2.01	0.72, 5.65	0.185
	Father only overweight	1.85	0.64, 5.34	2.52	1.19, 5.35	0.016
	Both parents overweight	4.32	2.05, 9.14	2.91	1.31, 6.48	0.009

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
Child's behaviour	Duration of breast feeding (months)	0.96	0.92, 1.00	0.96	0.92, .99	0.040
	Duration of sleeping (hours)	0.75	0.53, 1.06	_	_	_
	Energy (kcal)					
	Lowest	0.00				
	Medium	0.93	0.64, 1.37	_	_	_
	Highest	0.94	0.57, 1.52	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	0.92	0.68, 1.23	_	_	_
	Highest	1.07	0.74, 1.54	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	1.20	0.85, 1.71	_	_	_
	Highest	1.26	0.92, 1.71	_	_	_
	Carbohydrate (g)					
	Lowest	1.00				
	Medium	0.77	0.53, 1.12	_	_	_
	Highest	0.95	0.69, 1.30	_	_	_
	Sedentary activity (hours)	0.94	0.83, 1.06	_	_	_
	TV viewing (hours)	0.86	0.71, 1.04	_	_	_
	Vigorous activities (hours)	0.83	0.69, 0.99	_	_	_
Child;s characteristics	Age (months)	1.00	0.98, 1.03	1.07	0.99, 1.16	0.100
	Birth weight (100 grams)	1.08	1.01, 1.14	_	_	_

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ Data were not available

Table 8-22 presents the significant predictors for the development of obesity over the one year period in boys aged four to five years. At the community level, there was a borderline statistically significant lower risk of developing obesity observed in those children whose parents believed their neighborhood areas were safe (RR: 0.63, 95% CI: 0.40, 1.01; p=0.054). There were no factors at the preschool level that were statistically significant.

At the family environment level, only the good home environment score was shown to be statistically significantly associated with the risk of development of obesity in boys. Children with the highest good home-food scores were at lower risk of being obese (RR: 0.55, 95% CI: 0.33, 0.94).

At the parental characteristic level, the importance of parental overweight was underscored in the analysis. Children whose parents were both overweight were 1.71 times (95% CI: 1.01, 2.92) more likely to develop obesity over one year of follow-up compared with those whose parents were of normal weight. Furthermore, an increased relative risk of being obese was seen in those whose mothers attained college or university education (RR: 3.03, 95% CI: 1.09, 8.38) compared with mothers with primary education.

There were no statistically significant associations between dietary intake or physical activity patterns and the risk of developing obesity. The protective effects of longer duration of breast feeding and longer duration of sleep at night against developing obesity over time were confirmed. For each additional month of breast feeding, children were 0.96 times (95% CI: 0.94, 0.99) less likely to develop obesity over the one year follow-up. Similarly for each additional hour of sleep at night children were 0.76 times (95% CI: 0.58, 0.99) less likely to develop obesity.

There were no statistically significant factors at the child's characteristic level, including age, birth weight, materinal weight gain during pregnancy, gestational diabetes, premature birth, and birth order.

Table 8-22 Hierarchical model of predictors for the development of obesity in boys

The adjusted relative risk and the 95% confidence intervals of predictors for the development of obesity in boys over the one year of period from the GEE model

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
	Study time	1.06	0.98, 1.14	0.89	0.69, 1.17	0.41
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	1.01	0.69, 1.48	_	_	_
	Safety of environment					
	Yes[2]	0.73	0.48, 1.13	0.63	0.40, 1.01	0.054
School environment	Amount of play equipment	1.00	0.97, 1.02	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	0.64	0.36, 1.14	_	_	_
	Highest	0.82	0.51, 1.31	_	_	_
Family environment	Wealth index					
	Poorest	0.00				
	Medium	0.84	0.49, 1.43	_	_	_
	Wealthiest	1.39	0.88, 2.19	_	_	_
	Cognitive scores					
	Lowest	0.00				
	Medium	1.61	0.96, 2.72	_	_	_
	Highest	1.68	1.01, 2.81	_	_	_
	Emotional scores					
	Lowest	0.00				
	Medium	0.98	0.47, 2.03	_	_	_
	Highest	1.05	0.54, 2.06	_	_	_
	Home food environment score					
	Lowest	0.00		0.00		
	Medium	0.91	0.59, 1.41	0.81	0.51, 1.28	0.373
	Highest	0.59	0.34, 1.03	0.55	0.33, 0.94	0.029
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.92	0.51, 1.66	_	_	_
	Overweight	1.13	0.71, 1.78	_	_	_
	Parental BMI status					
	Neither parent overweight	0.00		0.00		
	Mother only overweight	1.25	0.78, 2.00	1.17	0.74, 1.87	0.497
	Father only overweight	1.23	0.56, 2.70	1.34	0.59, 3.03	0.477
	Both parents overweight	1.70	1.02, 2.85	1.71	1.01, 2.92	0.047

Levels	Predictors	Unadjusted Relative Risk	95% CI	Adjusted Relative Risk	95% CI	p-value[1]
	Mother education level					
	Primary school	0.00				
	Secondary school	1.43	0.54, 3.75	1.50	0.53, 4.23	0.44
	High school	2.25	0.89, 5.67	2.36	0.86, 6.49	0.095
	College/ University	2.81	1.09, 7.25	3.03	1.09, 8.38	0.033
Child's behaviour	Duration of breast feeding (months)	0.97	0.94, 0.99	0.96	0.94, 0.99	0.008
	Duration of sleeping (hours)	0.72	0.55, 0.93	0.76	0.58, 0.99	0.040
	Energy kcal					
	Lowest	0.00				
	Medium	0.88	0.72, 1.07	_	_	_
	Highest	0.93	0.78, 1.10	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	1.05	0.88, 1.24	_	_	_
	Highest	1.15	0.91, 1.45	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	0.98	0.77, 1.26	_	_	_
	Highest	1.11	0.97, 1.35	_	_	_
	Carbohydrate (g)					
	Lowest	1.00				
	Medium	1.03	0.82, 1.30	_	_	_
	Highest	1.06	0.91, 1.22	_	_	_
	Sedentary activity (hours)	0.99	0.95, 1.04	_	_	_
	TV viewing (hours)	1.02	0.93, 1.11	_	_	_
	Vigorous activity (hours)	0.97	0.89, 1.06	_	_	_
Child's characteristics	Age (months)	1.01	0.99, 1.02	1.03	0.98, 1.07	0.252
	Birth weight (100 grams)	1.05	1.01, 1.10	_	_	_

[1] p-value for adjusted coefficients were calculated from the multivariate GEE analysis
[2] No is reference
_ *Data were not available*

Table 8-23 summarises the significant findings of predictors for changes in adiposity and development of overweight and obesity.

Table 8-23 Summary of the significant predictors for changes in adiposity and development of overweight and obesity over time

		Changes in adiposity over one year period										Development of			
		BMI		TSF		SSF		SISF		Sum of SF		Overweight		Obesity	
Levels	Predictors	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Community	Neighbourhood safety	**-**	**-**	**-**	-	**-**	-	**-**	-	**-**	**-**	-	-	**-**	-
Preschool environment															
	Number of play equipments	-	+	-	**-**	**-**	-	+	+	-	+	-	-	-	-
	School food environment scores	-	+	-	+	+	+	+	+	+	**+**	-	+	-	**+**
Family environment															
	Wealth household index	**+**	+	**+**	+	**+**	+	**+**	+	**+**	+	**+**	**+**	+	**+**
	Cognitive scores	**+**	-	**+**	+	**+**	+	**+**	+	**+**	+	**+**	-	+	-
	Emotional scores	+	**+**	+	**+**	+	+	+	**+**	+	**+**	+	+	+	+
	Home food environment scores	-	**-**	**-**	-	**-**	-	**-**	**-**	**-**	**-**	-	**-**	**-**	-
Parental characteristics															
	Maternal pre-pregnant BMI status	+	**+**	+	+	+	**+**	+	+	+	+	+	+	+	+
	Parental BMI status	**+**	+	+	+	+	+	+	+	+	+	**+**	**+**	**+**	**+**
	Father education level	**+**	+	+	+	+	+	+	+	+	+	+	+	+	+
	Mother education level	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+
	Paternal occupations	+	+	+	**+**	+	**+**	+	**+**	+	**+**	+	+	+	+
Child's dietary, PA behaviours, sleep pattern															
	Duration of breast feeding months	**-**	-	**-**	-	**-**	-	**-**	**-**	**-**	-	-	-	**-**	**-**
	Duration of sleeping hours	-	-	-	-	-	-	-	-	-	-	-	-	**-**	-
	Protein (g)	+	-	+	-	**+**	-	+	-	**+**	-	+	+	+	+
	Carbohydrate (g)	-	+	+	+	+	+	+	+	+	+	+	**+**	+	+
	TV viewing (hours)	+	+	+	+	+	+	+	**+**	+	+	**+**	**+**	+	+
	Vigorous activities (hours)	+	+	-	-	+	-	-	-	-	+	**-**	**-**	-	-
Child's characteristics															
	Age (months)	+	+	**+**	+	**+**	+	**+**	**+**	**+**	+	+	+	+	+
	Birth weight (100 grams)	**+**	+	**+**	**+**	+	+	+	+	**+**	+	+	+	+	+

***+** a significant increase*   *+ insignificant increase*

***-** a significant decrease*   *- insignificant decrease*

8.4 Discussion

This one year cohort study has identified factors associated with changes in adiposity and the development of overweight and obesity in children aged four to five years in the urban areas of Ho Chi Minh city, Vietnam over a one year period from 2005 to 2006. The importance of a safe neighborhood, preschool play equipment, preschool food environment, family environments (including household wealth status, cognitive and emotional stimulation), parental overweight status, higher dietary intake of protein and carbohydrates, physical activity patterns (including vigorous activity and sedentary behavior such as TV viewing), have been identified as risk factors in the different models of determinants for changes in adiposity indicator, and the development of overweight and obesity over time for boys and girls.

The results indicate that different risk factors can be found at each level. At the community level, the protective effect of the safety of the neighborhood as perceived by parents, was consistent across the different measures for adiposity, but this effect appeared to be more pronounced in boys than in girls. There has been increasing recognition of the importance of considering the context in studying the aetiology of individual's health outcomes including childhood obesity (Diez-Roux, 1998, Birch and Davison, 2001). Previous research has emphasized the influence of perceptions of neighborhood safety or the level of neighborhood economic development, on childhood obesity or obesity-related behaviour (Burdette and Whitaker, 2004, Timperio et al., 2004, Timperio et al., 2005, Lumeng et al., 2006, Merchant et al., 2007).

Neighborhood features may affect a child's weight through a number of ways such as influencing a child's level of physical activity, or by affecting a child's food consumption. Children aged five to six years were observed to be less likely to engage in walking and cycling when their parents believed there was heavy traffic and limited public transportation in their area (Timperio et al., 2004). Furthermore, the safety of residential areas as perceived by parents, has been reported to be positively associated with sedentary activity such as TV viewing in 3 year old children (Burdette and Whitaker, 2005). For neighborhood safety ratings by parents in the lowest quartile, there was an increased risk of overweight at the age of seven years compared with children with safety ratings in the highest quartile (adjusted odds ratio, 4.43; 95% confidence interval, 2.03-9.65) (Lumeng et al., 2005).

There have been few studies examining whether the effects of the neighborhood environment on the child's weight differs by gender. A cross sectional study has reported an increased likelihood of being overweight for boys but not girls, if there was garbage, litter, or broken glass on the street or sidewalk (Irina, 2007). In the present study, the role of the environment safety on the child's weight change was consistent across the range of indicators of adiposity (BMI, individual and the sum of skinfold thicknesses) in boys and the combined gender analyses, whilst this effect was found for BMI and the sum of skinfold thickness measurement changes in girls. Perhaps, comparison of the combined gender models, gender specific models with smaller sample size may be under-powered to detect this association. However, the findings in the current study have highlighted how important the safety of the environment was on the child's weight status and these findings were similar to reports about environmental factors associated with childhood overweight in developed countries.

In addition to the safety of the community, economic level of the community was another aspect that was found to be linked with development of overweight in children. In Western countries, children living in low income communities have been found to be at higher risk of obesity (Oliver and Hayes, 2005). It has been suggested that lower economic levels of the community indirectly influence the child's overweight status through the lower quality of physical activity facilities, accessibility to healthy food and recreational facilities (Moore and Diez Roux, 2006, Gordon-Larsen et al., 2006). In contrast, the current study found a significant association between wealthier residential areas and the change in suprailiac skinfold thickness over time. Nevertheless, this association was only seen in girls and was not consistent across the other indicators of adiposity. From the findings of the baseline study, overweight prevalence in this child population has spread throughout the urban areas of HCMC (Chapter 4), and it appears that the economic level of urban districts of HCMC might have narrowed and may no longer be apparent as a factor promoting overweight in this child population.

The availability of fast food outlets in the neighborhood has been noted as promoting more consumption of energy-dense foods in developed countries such as the United States (St-Onge et al., 2003). Yet in this study, no significant association was found between the availability of Western and local fast food outlets in the neighborhood and the change in adiposity and overweight or obesity in children aged four to five years. Nevertheless, the role of specific characteristics of the community on adiposity and development of overweight in the young child population in HCMC needs further evaluation. Such future evaluation needs to use more objective assessments of the safety of neighborhoods, the availability, and accessibility to healthy foods, and facilities for physical activity.

The preschool setting plays a major role in shaping the dietary intake and physical activity of young children; therefore, it is an important setting for preventing childhood obesity (Story et al., 2006). Research assessing the children's physical activity patterns in preschools has documented a strong contribution to levels of physical activity of the preschool environment compared with other factors such as gender or race (Finn et al., 2002, Pate et al., 2004). Children attending preschools with better resources and more college educated teachers, were observed to engage in more moderate to vigorous activity and in less sedentary behavior than children from lower quality preschools (Dowda et al., 2004). In the study reported here, the preschool resources such as the size of the school yard and the number of items of play equipment, and the food environment in the vicinity of the preschool, were examined. The benefit of preschool's resources, such as accessibility to the play equipment, was seen to protect children from excessive increases in triceps skinfold thickness in girls and subscapular skinfold thickness in boys. As noted in the literature, the policies and practices in preschools might have an important influence on the overall activity levels of the children (Dowda et al., 2004). Thus, it is important to have more careful investigations of the impact of preschool policies and practices, as well as the availability of resources at preschools, on the level of physical activity in this child population.

In the group of factors at the preschool level, the food environment factors (the availability of sweets, snacks, and ice-cream within a two hundred meter diameter around the preschool), were found to be associated with the change in the sum of skinfold thickness measurements and the development of obesity over time. Again, this association was seen in girls rather than boys but was not found in the combined gender models. The food environments in the neighborhood areas have received more attention than in the preschool setting in epidemiological studies of childhood obesity (Richter et al., 2000, St-Onge et al., 2003). Although sweets and snack foods are not allowed to be sold within preschools, this study has found that the contribution of the food environment in the vicinity of the preschool on the child's weight status had greater influence for girls than boys.

The childhood obesity epidemic has been considered to originate from the family, as obese parents provide both genes and an obesogenic environment to their offspring (Cutting et al., 1999, Birch and Davison, 2001). There are various aspects of the home environment that have been identified as predicting obesity in children. Results from studies in developed countries have shown that children from low income households, from lower family education and from non-professional parents, were associated with a higher risk of becoming obese (Strauss and Knight, 1999, Zaimin et al., 2002, Danielzik et al., 2004, Lamerz et al., 2005, Stamatakis et al., 2005). In contrast, the current study found children from the wealthiest families demonstrated a significant increase in adiposity and risk of development of obesity over time compared with those from the poorest families. These findings are in agreement with other studies on preschool children and adolescents conducted in developing countries, where household economic status, higher education and professional parents were noted to be positively associated with the development of obesity in children (Sakamoto et al., 2001, Luo and Hu, 2002, Hong, 2005, Ming, 2006).

However, there was a gender difference in the association between household wealth status, parental education level, and parental employment, and the change in child's weight over time. The role of the household economic status on the child's weight was consistent across a range of adiposity measures and the development of overweight in boys and the combined gender models whilst this was only seen in models predicting development of overweight and obesity in girls. Higher education levels in parents were shown to have an effect on change in BMI and predicted the development of overweight in boys, while such effects were not observed in girls. In contrast, paternal employment in professional work was found to be a predictor of adiposity change in girls but not in boys. Most studies in developed countries have reported the role of economic status with the development of obesity in children in analyses with combined genders (Strauss and

Knight, 1999, Lamerz et al., 2005, Stamatakis et al., 2005). Yet in a cross-sectional study of children aged 5 to 7 years in Germany, socioeconomic status appeared to have a greater impact on the development of overweight in boys compared with girls (Danielzik et al., 2004). Although this finding was in line with the findings in HCMC, the inconsistent findings of the role of the household wealth index on the child's weight between the combined gender and gender specific models, may suggest that this is due to the smaller sample size in gender specific models.

There is evidence in the literature that the quality of the home environment plays an important role in the child's physical and intellectual development and may also contribute to the development of obesity in children (Bradley et al., 1996, Strauss and Knight, 1999). Using the Home Observation for Measurement of the Environment Short Form (HOME-SF) to measure the quality and quantity of home environment, American children from birth to eight years old with lower cognitive stimulation or a poorer home environment, were reported to be at higher risk of being overweight at the six-year follow-up compared with those having the highest cognitive stimulation (Strauss and Knight, 1999). This measurement instrument was modified and employed to assess the quality of home environment in terms of cognitive stimulation and emotional support for preschoolers in HCMC in this study. The findings from the combined gender models also highlighted the role of cognitive stimulation of parents on the changes in adiposity in their child, but with different implications from those reported in the US (Strauss and Knight, 1999). Children with the higher cognitive stimulation scores were more likely to have significant increases in BMI, and in the individual and the sum of skinfold thicknesses measurements over time. Similarly, a higher emotional support elevated the risk of developing overweight in children of both genders.

However, the findings from gender specific models have shown different patterns in how the quality of the home environment influenced the development of obesity in both genders. The highest cognitive score was shown to be a strong determinant of changes in BMI, and the individual and the sum of skinfold thicknesses measurements in boys. In contrast, the highest emotional scores were associated with changes in BMI, triceps, suprailiac and sum of skinfold thickness measurements in girls. This study is unable to explain how the quality of the home environment has a different impact between boys and girls. Further investigation is needed to understand this gender difference.

Household socioeconomic status (SES) has been observed as being associated with the quality of the home environment in both developed and developing countries but with different influences in these different types of countries. The findings of a study from America indicated that lower cognitive stimulant coupled with lower socioeconomic status (SES) resulted in a higher risk of developing overweight over time (Strauss and Knight, 1999). Moreover, low SES was reported to be associated with an unhealthy diet, including greater consumption of high energy foods and lesser consumption of fruit and vegetables (Merchant et al., 2007) and children raised in poor families were more likely to engage in sedentary behavior such as spending more time viewing TV, and playing video-games (Garemo et al., 2007). Children in this study, who were from wealthy families, had the highest score of cognitive and emotional stimulation and demonstrated a significant change in adiposity and an increased risk of becoming overweight over time. Thus, there are differences in the role of SES and the quality of home environment in the development of childhood obesity in developed countries and in developing countries such as Vietnam, that should be considered when developing prevention programs in the future.

A number of studies have reported that overweight parents were a significant predictor for the development of overweight in their offspring, especially when both parents were obese (Whitaker et al., 1997, Danielzik et al., 2002, Zaimin et al., 2002, Treuth et al., 2003, Danielzik et al., 2004, Mamun et al., 2005, Reilly et al., 2005). Others investigating the role of maternal pre-pregnant overweight status on obesity in the offspring later in life, have reported that children who were born to overweight mothers were at increased risk of becoming obese (Baker et al., 2004, Whitaker, 2004, Salsberry and Reagan, 2005). The current study has provided more evidence of the impact of overweight parents on the risk of development of childhood obesity, although the evidence was not consistent across the indicators of adiposity. The overweight status of mothers before the pregnancy was shown to predict changes in BMI and subscapular skinfolds in girls, while negative findings were observed in boys. The effect of maternal pre-pregnant overweight has received more attention in studies of the aetiology of childhood obesity because of the importance of early prevention (Whitaker and Dietz, 1998). However, the role of maternal overweight status does not appear to be a strong determinant of obesity in this child population, as this effect was not consistent across the different measures of adiposity in the combined gender and gender specific models. Furthermore, maternal overweight assessed at the baseline was not shown to be associated with the development of overweight and obesity in children aged four to five years, whilst paternal overweight at the baseline was significantly related to the change in triceps skinfold thickness and development of overweight and obesity. However, the strongest impact of parental overweight status on their offspring's risk of obesity was seen in those whose parents were both overweight.

Although it is difficult to differentiate between heredity and environmental influences, there is evidence suggesting an important genetic contribution to the obesity epidemic in children (Bell et al., 2005, Jacobson et al., 2007). Obese parents may not only transmit a genetic predisposition to excess weight gain but they also shape the dietary and physical activity patterns of their children and can create an obesity-promoting environment for their children. Children who grew up in obesogenic families were reported to have a higher preference for fatty foods, lower preference for vegetables and exhibited aspects of a disinhibited eating style (Wardle et al., 2001). Other studies have observed a lower physical activity level and higher sedentary behaviour in preschool children whose parents were overweight (Klesges et al., 1990, Davison et al., 2005). At the family level, therefore, it has been widely accepted that prevention and treatment of childhood obesity should use multifaceted family based programs with parental involvement (Jana and Andrew, 2001a).

Since obesity at the individual level is ultimately a result of energy imbalance, investigating the child's dietary intake and physical activity behaviour has received major attention in the study of determinants of childhood obesity. Although it has been hypothesized that childhood obesity could be associated with high total energy intake, there is little supporting evidence for this association (Schonfeld-Warden and Warden, 1997). A review of the aetiology of obesity in children has noted that obese children did not intend to overeat (Schonfeld-Warden and Warden, 1997) and the mean energy intakes were not significantly associated with changes in weight or BMI over time in two prospective studies (Maffeis et al., 1998, Magarey et al., 2001). Similarly, there was no association between total caloric intake with change in adiposity or the development of overweight and obesity in children aged four to five years in HCMC.

It has been suggested that the relationship of macronutrients to energy imbalance, derives from their effects on hunger, satiety, satiation, and food intake (Stubbs et al., 1997). Higher fat intake at baseline and increased fat intake over a two year follow-up were reported to be associated with greater gains in BMI in a three year cohort study among preschool children aged three to five years (Klesges et al., 1995). Another four-year longitudinal study found an increase of 1.5 standard deviations in the sum of seven skinfold thickness measurements related to a higher percentage of energy from fat among children aged four to seven years (Robertson et al., 1999). In the current study, there was no significant association between dietary fat and change in adiposity or the development overweight and obesity. No associations or very few significant associations between fat intake or percentage of energy from fat and change in BMI or the child's weight, have been reported in other longitudinal studies (Rolland-Cachera et al., 1995, Magarey et al., 2001).

There was a positive association between higher longitudinal protein consumption with changes in subscapular, the sum of skinfold thickness measurements in boys, while higher longitudinal intake of carbohydrate was positively associated with the development of overweight in girls in this study. However, evidence of the association between protein intake with the development of obesity in children is unconvincing, and no significant association has been reported in a number of studies (Atkin and Davies, 2000, Grant et al., 2004). Furthermore, several longitudinal studies have observed that protein intake earlier rather than later in life, might have an effect on the development of obesity in children by programming for later obesity, and that is possibly associated with the adiposity rebound (Rolland-Cachera et al., 1995, Skinner et al., 2004).

The role of carbohydrate in relation to childhood obesity has also been considered to be inconclusive in review of the literature with conflicting results from cross-sectional and longitudinal studies (Newby, 2007). The inverse association between carbohydrate intake, expressed as a percent of energy from carbohydrate, and obesity in young children was reported in the majority of cross-sectional studies. However, non-significant associations were documented in all longitudinal studies except for one six-year follow-up study carried out in two year old children (Newby, 2007). In contrast, there has been increasing concern that carbohydrate related to energy density and energy dense foods are likely to be palatable and liable to be overeaten. Furthermore, it has been proposed that the concurrent consumption of fat and carbohydrate has a synergistic effect and strong stimulus on energy density (Livingstone and Rennie, 2006). Nevertheless, this hypothesis has not been well established in children (Newby, 2007).

Thus, in this study there was inadequate evidence to support the role of protein and carbohydrate consumption in the development of overweight in the child population, and these associations were inconsistent across the range of adiposity indicators. It is difficult to measure dietary intake, particularly in children (Livingstone and Robson, 2000). Also, there are a number of issues that need to be addressed when studying the association between dietary intake and childhood obesity. Confounders, especially reporting bias involving proxy reporters of diet consumption in young children, the growth of the child and genetic influences, may all contribute to the lack of association between nutrient intake with childhood obesity (Newby, 2007). Therefore, a comprehensive review of studies of the role of diet in childhood obesity has recommended that additional, well-designed studies that take account of these methodological issues, are needed (Newby, 2007).

Several epidemiological studies have reported a relationship between ice-cream, soft drink and fast food consumption, and obesity in preschool children (St-Onge et al., 2003, Newby et al., 2003, Welsh et al., 2005). A 2004 cross sectional study of adolescents in HCMC has also reported higher odd ratios of being overweight for those who consumed soft-drinks more frequently

(Hong, 2005). However, such associations were not observed in this study. of preschool aged children. These null findings were also noted in a number of studies in which the quantitative information on fruit juice and soft drink were used to examine the relationship with the trajectory change in BMI (Newby et al., 2004, O'Connor et al., 2006). A possible explanation is that fruit juice, soft drink and fast food consumption might contribute less to the change in the child's weight. However, future research needs a more detailed assessment of the influence of consumption of sweet beverages, snacks, and fast foods when examining the determinants of obesity in young children.

The long-term effect of breast feeding on adiposity remains controversial. There have been conflicting results about the role of breast feeding as a protective factor against later obesity. Although a number of studies have reported no association between breast feeding with obesity later in life (Burke et al., 2005, Parsons, 2006), there have been at least three systematic reviews on the association between breast feeding and subsequent obesity that have noted a small but consistent protective effect of breast feeding against obesity in children (Arenz et al., 2004, Harder et al., 2005, Owen et al., 2005). Each month of breastfeeding was reported to be associated with a significant 4% reduction in obesity risk (95% CI: 2% to 6%) in a meta analysis of 16 longitudinal studies and one case-control study (Harder et al., 2005). A similar strength of effect was observed in this one year cohort study. For each additional month of breast feeding, there was a significant 4% reduction in the risk of developing obesity in children of both genders, over the study. In addition, a small protective effect of breast feeding on change in adiposity was documented in this study. This association was consistent across a range of adiposity indicators in which a significant reduction in BMI, individual and the sum of skinfold thickness measurements ranged from 0.04 to 0.07 measurement units in the combined gender models. However, the findings from gender specific models have indicated a gender difference in the relationship between breast feeding and the changes in adiposity measures. The protective effect of breast feeding appears to be more obvious in boys than in girls. Longer duration of breast feeding was associated with a significant decrease in BMI, triceps, subscapular, suprailiac and the sum of skinfold thickness measurements in boys whilst this association was only found in change of suprailiac skinfold thickness in girls. It is not possible to provide an explanation of this gender difference in the present study. Additionally, as noted earlier in this discussion, the smaller number of children examined in gender specific models may account for the inconsistent findings across different measures of adiposity between boys and girls. Nevertheless, the findings of this study suggest that future research may need to examine whether the health benefit of longer breast feeding differs by gender.

Several prospective studies using different methods to measure physical activity, including accelerometers, heart rate monitors or parent proxy-reports, have observed that higher levels of physical activity have a small effect on reducing body fat in children (Marshall et al., 2004, Must and Tybor, 2005). Additionally, sedentary behaviour may play an important role in increasing the prevalence of obesity in children and decreasing sedentary behaviour has been shown to be an effective strategy against childhood obesity in prevention studies (Epstein et al., 2000, Reilly et al., 2002, Must and Tybor, 2005). It has been proposed that physical inactivity promotes increased calorie consumption and therefore contributes to the development of obesity later in life (Robinson, 2001, Marshall et al., 2004). Studies using TV and video viewing as an index for physical inactivity, observed that children who watched the most TV demonstrated a greater increase in body fat measured by BMI, triceps, and the sum of five skinfold measurements over time (Proctor et al., 2003, Jago et al., 2005). In this study, using proxy reports given by teachers and parents to assess physical activity, there were some significant associations between time spent in vigorous activity and viewing TV, and the changes in adiposity and the development of overweight children in both genders in univariate analysis. However, in the multivariate analysis, these associations only remained in the model that predicted the development of overweight. Children of both genders who engaged in vigorous physical activity the most, were at lower risk of development of overweight over time with a similar protective effect observed for boys and girls (RRs: 0.76, 95% CI: 0.65, 0.88; 0.77, 95% CI: 0.67, 0.89 respectively). Meanwhile, the influence of TV viewing, a type of sedentary behaviour, on the risk of being overweight was seen in the combined gender model in which each additional hour of TV viewing elevated the risk of being overweight by 1.08 times (95% CI: 1.01, 1.16). However, this association was only seen for boys in gender specific analysis (RR: 1.12, 95% CI: 1.03, 1.21). Thus, in both the combined gender and gender specific models, the influences of vigorous activity and TV viewing were linked only with the overweight risk, but null findings were found for BMI, skinfold thickness and for the risk of development of obesity. Furthermore, other types of sedentary behaviour such as physical inactivity and naps, assessed as absolute time and percentage for all daily sedentary behaviour, were not significantly associated with changes in adiposity or risk of developing overweight and obesity.

There have been inconsistent findings reported in the literature for associations between high levels of physical activity and sedentary behaviour and the development of childhood obesity (Must and Tybor, 2005). The explanation could be the lack of valid methods to measure physical activity and sedentary behaviour in epidemiologic studies of childhood obesity (Must and Tybor, 2005, Bryant et al., 2007). Although proxy questionnaires are the most common method used to measure physical activity in young children (due to their low cost and feasibility when measuring physical activity with a large number of children), their weaknesses have been recognised. Important limitations of a proxy questionnaire administered to a third person is the extent to which the respondent has an opportunity to observe the child's physical activity, and the potential for reporting bias (Sallis and Saelens, 2000). Moreover, low correlation coefficients have been observed between questionnaire reports of physical activity with criterion methods (Sallis and Saelens, 2000).

In the current study, the proxy questionnaire aimed to assess the highest level of physical activity and sedentary behavior and it was validated against accelerometers as a criterion method. There were low correlation coefficients for reported vigorous activity given by the teachers and parents ($r = 0.1722$, $p=0.2367$) and for TV viewing reported by parents compared with the sedentary time measured from accelerometers ($r = 0.09$, $p=0.5257$). The limited performance of the proxy questionnaires may help explain the inconsistent findings in this study for the effects of vigorous physical activity and TV viewing on indicators of adiposity.

Based on cross sectional data from the baseline, longer duration of sleep at night was found to be associated with a lower risk of being overweight and obese (adjusted PRs: 0.87, 95% CI: 0.78, 0.98; 0.75, 95% CI: 0.60, 0.94). However, the protective effects of a longer sleep on longitudinal change in adiposity and the risk of developing overweight and obesity were not confirmed in this one year cohort study. The univariate analysis showed weak associations between longer duration of sleep and significant decrease in BMI and a decreased risk of overweight in girls. But such associations disappeared in the multivariate analysis. The only significant association between less sleep and decreased risk of developing obesity over time, was found for children in the combined gender model after adjusting for other factors. However, this effect was only seen for boys in gender specific analysis where there was no significant association between longer hours of sleep and risk of being obese in girls, in both univariate and multivariate analysis. Thus, in this study, there was inadequate evidence of the role of sleep in the development of obesity.

There has been a growing interest in the effect of sleep on the development of overweight in children with a number of cross-sectional and prospective studies reporting the association between short sleep duration and obesity (Sekine et al., 2002, von Kries et al., 2002, Reilly et al., 2005, Chaput et al., 2006). Although the mechanism for the role of sleep in predisposing obesity is still unclear, there was some evidence suggesting a mechanistic link relating metabolic hormones and sympathetovagal balance that may lead to an energy imbalance (Taheri, 2006). From the point of obesity prevention, along with the benefits of adequate sleep on health and academic performance, adequate sleep should be supported in prevention programs of childhood obesity, though additional evidence for such effects are needed (Taheri, 2006).

It has been suggested that a genetic predisposition to fat gain, may underlie the risk of children developing obesity when exposed to a particular environment (Bouchard and Perusse, 1988). Therefore, the child’s biological characteristics such as gender and age may interact with energy imbalances influencing the child’s weight status (Davison and Birch, 2001b). In this study, models of determinants for changes in adiposity and the risk of developing overweight and obesity were examined separately for boys and girls. As mentioned previously, there were gender differences in the risk factors for change in adiposity in the children over time. Boys appeared more likely than girls to gain weight and increase their adiposity. For each additional month of age for boys, a significant increase in triceps, subscapular, suprailiac and the sum of skinfold thickness measurements (0.17-0.32 mm) was observed. At the baseline study, the prevalence of obesity in boys was shown to be significantly higher than for girls and this difference was consistent at two follow-up measurements (Table 8-11). Furthermore, the prevalence of overweight in boys assessed at the end of follow-up was significantly higher than that at the baseline study. Similar patterns of gender difference in obesity has been reported for adolescents from urban areas of HCMC (Hong, 2005), where, the adjusted odds of being overweight in boys was reported to be 3.10 (95% CI: 1.79, 3.75) times higher than in girls. This finding is in agreement with the other studies of adolescents in China (adjusted odd ratio: 1.5, 95% CI: 1.1, 2.2) (Ming, 2006). In contrast, studies of childhood obesity carried out in developed countries have documented an opposite result, where girls were at higher risk of developing overweight than boys (Zaimin et al., 2002, Mamun et al., 2005).

It is unclear why these gender differences vary between the two study settings of developing and developed countries. Perhaps male gender preference is more common in developing countries and may contribute to this difference in gender patterns in obesity development because boys are better nourished and receive more of the family's resources, than girls. However, future studies need to explore this hypothesis.

There has been increasing interest in studying the relationship between early life experiences such as intrauterine growth and later risk of obesity (Whitaker and Dietz, 1998, Oken and Gillman, 2003). There is extensive evidence of a relationship between large birth size and subsequent risk of obesity, especially in preschool children (Whitaker and Dietz, 1998, Martorell et al., 2001, Oken and Gillman, 2003, Reilly et al., 2005, Dubois and Girard, 2006). Furthermore, research findings have suggested maternal weight gain during pregnancy is also associated with birth size and the risk of their offspring developing obesity (Whitaker, 2004, Oken et al., 2007).

In the present study, there was an association between high birth weight and change in adiposity. A linear relationship between birth weight and change in BMI was seen in both genders and for triceps skinfold thickness in boys. However, no significant associations were found for subscapular, suprailiac, the sum of skinfold thicknesses measurements or the development of overweight and obesity. Additionally, maternal weight gain in pregnancy, another proxy of intrauterine growth, appears to have no effect on change in adiposity and the development of overweight in this child population. The positive relationship between maternal weight gain in pregnancy and change in BMI in the univariate analysis for boys, disappeared after adjusting for other factors in the multivariate model. Thus, there was inadequate evidence in the current study to support an association between intrauterine growth and change in adiposity.

Evidence from the literature has shown that early adiposity rebound in childhood is a critical phenomena associated with later obesity and unfavourable diseases such as hypertension, impaired glucose tolerance, and diabetes in childhood and adulthood (Rolland-Cachera et al., 1984, Dietz, 1994, Taylor et al., 2005). The magnitude of the effect has been reported to be more considerable for children experiencing adiposity rebound early (<5 years of age) compared with a late rebound (>7 years of age) (Freedman et al., 2001). In this study, factors predisposing to a rapid increase in BMI over a one year period in children aged four to five years were investigated. It is possible that some children may have experienced an early adiposity rebound during this study time period. However, it has been suggested that early adiposity rebound can predict later obesity because it identifies children whose BMI centile is high and/or crossing upwards (Cole, 2004). Thus, the association of BMI centile crossing is statistical not physiological, applies at all ages and not just at the rebound (Cole, 2004). It is therefore the identification of children who undergo a rapid increase in BMI during these years that appears to be more important than determining the timing of adiposity rebound. Finally, it is less likely that an early adiposity rebound could be detected in a cohort followed over such a short period of time with only three measurements of BMI over one year.

This study has many strengths. Firstly, the response rate was relatively high (78.5%). There were no significant differences in the characteristics of children who participated in the follow-up and those who dropped out. The findings, therefore, were representative of children aged four to six years in preschool settings in HCMC. Secondly, the associations between risk factors and changes in adiposity indicators and the development of overweight and obesity over the period of one year were assessed using an hierarchical conceptual framework. This appropriate modeling strategy did not rely entirely upon statistical significance and allowed interpretation of the findings in the light of social and biological knowledge (Victora et al., 1997). Thirdly, a wide range of potential confounding factors were used in the analyses to adjust the effect measures of the potential risk factors. Fourthly, gender specific models of predictors of adiposity and risk of overweight and obesity were performed because of the observed gender interaction with these outcomes over time. Lastly, the GEE models simultaneously assessed the associations between longitudinal development of adiposity, and overweight and obesity status, and the predictors such as dietary intake and physical activity patterns at different points of time (Twisk, 2003).

There were a number of limitations in this study that should be taken into account when interpreting the findings. Firstly, as mentioned in Chapter 4, this study was performed in the preschool setting with an attendance rate for children aged four to six years at about 80%. Thus, there was another 20% of children who did not attend these childcare centres, and as such, were not available for recruitment for this follow-up study. Therefore, it is difficult to generalize the findings to the overall child population of this age group in HCHC.

Secondly, BMI and skinfold thickness were used as surrogate measures of body fatness. However, the precision and specificity of skinfold thickness has been evaluated in the literature. These measurements have considerable inter- and intra-observer error, particularly for fatter children (Weststrate et al., 1989). In such cases, skinfold thickness is considered to underestimate the body fatness assessed (Weststrate et al., 1989) and so would diminish the association between the child's overweight and potential risk factors. Using BMI as a proxy of body fatness is another limitation in this study. Although this index is considered to have high reproducibility because of high reliability of weight and height measurements, it cannot distinguish the lean and fat masses (Troiano and Flegal, 1998). Additionally, the correlation between BMI and body fatness is known to vary by age, gender, and ethnicity (Troiano and Flegal, 1998, David et al., 2005).

Thirdly, some of the measurement instruments used were not validated before being employed in this study. The validation study of the physical activity proxy questionnaire was integrated into the cohort study, and it revealed low correlations between the data from proxy reports given by teachers and parents and that measured by accelerometers as the criterion method. The low performance of the proxy report questionnaires for physical activity, in terms of vigorous activity and TV viewing, might have accounted for the inconsistent associations between sedentary behaviour and a high intensity level of activity, and the change in adiposity and risk of developing overweight and obesity. In addition, the HOME-SF questionnaire, developed in the USA to examine the influence of the quality of stimulation and support available in the home environment on the child's growth and development, was only modified for use in this study. Although this approach has been validated for use in developing countries such as Indonesia and India, its validity has not been tested in Vietnam.

Fourthly, recall bias was another potential weakness of this study. Data on the child's characteristics, particularly information on birth history including birth weight, maternal pre-pregnant weight, maternal weight gain in pregnancy, diagnosis of gestational diabetes and breast feeding practice, relied on parental memory and so may have introduced bias. Similarly, information on the child's food intake over the preceding months was based on parental and teacher recall.

Fifthly, the inconsistent findings in some associations between potential risk factors (including the safety of the environment, the household economic status, the quality of the home environment in terms of cognitive and emotional stimulants, and breast feeding) and the child' weight change over time for both genders, may have been effected by the small sample size in the gender specific analysis.

Finally, the time of follow-up in this cohort study may not have been long enough to examine the long-term relationship between a number of risk factors and change in adiposity and development of overweight and obesity in this child population. For example, mean protein intake at two years or mean protein, fat, and carbohydrate intake over two to eight years, have been reported to predict body fat measured by BMI and skinfold thickness at eight years old (Rolland-Cachera et al., 1995, Skinner et al., 2004). Perhaps the timing of investigations such as dietary intake, may not match well with the timing of change in adiposity and obesity development, and the age of the studied children might be too young to show the effects of different levels of nutrient intake.

In summary, this one year cohort study provided evidence of the multifactorial nature of the aetiology of overweight and obesity of children aged four to six years in Ho Chi Minh City. There were different models of determinants to predict changes in adiposity and risk of developing overweight and obesity for boys and girls. At the community level, the safety of the neighborhood area was an important factor associated with weight change in both genders. Preschool environment (including the size of the school yard, the available play equipment, the ratio of teachers to students, and the food environment in the vicinity of the preschool) was also shown to contribute to the development of overweight in this population. There were different effects of economic status, emotional support, and cognitive stimulation in the home environment on childhood obesity development. Higher economic class, receiving more emotional support and cognitive stimulation from parents, were all associated with positive changes in adiposity and increased risk of developing overweight and obesity, although there were gender differences in these effects. For example, household wealth status and cognitive stimulation appeared to have more impact on boys whilst emotional support seemed to be a significant factor for girls. A good home-food environment was shown to have a protective effect against changes in adiposity and the development of obesity, and again this association appeared to be more apparent in boys than in girls. The findings also indicated the importance of parental weight status on excess weight gain of their offspring especially when both parents were overweight. Maternal pre-pregnant weight status was found to have an influence in change in adiposity over time in daughters rather than sons. Though the protective effect of a longer duration of breast feeding against changes in adiposity and obesity development was small, it was consistent, particularly in boys. There were few significant associations between food intake and physical activity with change in adiposity and risk of developing overweight. Higher protein and carbohydrate consumption was positively associated with change in subscapular and the sum of skinfold thickness measurements in boys and higher consumption of carbohydrate was associated with an increased risk of developing overweight over time. Children of both genders, who spent more time in vigorous activity, were less likely to develop overweight. Significant associations were also observed between longer duration of TV viewing and the risk of becoming overweight, in boys. High birth weight was not a strong predictor for change in adiposity and development of overweight in this child population and this association was only seen for change in BMI in both genders and triceps skinfold thickness in boys. Over the one year period of study, boys appeared to be more vulnerable to changes in adiposity as a linear relationship between age and change in adiposity was found for this group.

This is the first longitudinal study of risk factors for overweight and obesity carried out in preschool children in urban areas of Ho Chi Minh City, Vietnam. Although the study had some limitations, the findings have contributed to the knowledge of determinants for overweight development and obesity in this young child population. Since studies of the aetiology of childhood obesity in Vietnam are still sparse, the findings in this study have some importance in enabling the next step in tackling this epidemic, by conducting intervention programs and employing the assessment of determinants from this study. Suggestions and recommendations drawn from this study are presented in Chapter 9.

Chapter 9 Conclusions and recommendations

In this chapter, the key findings of the one year cohort study are summarised along with an overview of the strengths and limitations of the study. The implications of the main findings are discussed and suggestions for further research and possible prevention program(s) are presented.

9.1 Main findings and conclusions

This cohort study aimed to identify the determinants at multiple levels, of changes in adiposity including BMI, individual and sum of skinfold thickness measurements, and the development of overweight and obesity. It was conducted from 2005 to 2006 in a representative sample of children aged four to five years attending kindergartens in urban areas of Ho Chi Minh City, Vietnam.

There were five main findings. First, based on data from the baseline study evidence of a“nutrition transition” among the preschool child population in urban areas of HCMC was described. Regardless of whether the IOTF definition or the new WHO 2006 growth standard was employed to classify overweight and obesity, the prevalence of overweight and obesity was high and was coupled with a low prevalence of underweight in this child population. Using the IOTF definition, the prevalence of overweight and obesity was 20.5% (95% CI: 17.5, 24.3) and 16.3% (95% CI: 13.2, 20.4) respectively, with only 2.7% of children being underweight. The level of overweight/obesity was similar in both less wealthy and wealthy urban areas: 35.9% (95% CI: 29.4, 42.9) and 38.9% (95% CI: 32.3, 45.0) respectively. There was a large shift from under-nutrition to over-nutrition and this was irrespective of the household economic status, thus suggesting that overweight and obesity in preschool children in urban areas of HCMC has become an important public health problem.

This study identified a number of potential risk factors for developing overweight and obesity in this young child population including gender (i.e. boys), high birth weight, shorter duration of breast feeding, time asleep at night, and parental characteristics of BMI status and level of education.

The second main finding is that the significance of this health problem is not only its magnitude but also its rapid rate of increase. The prevalence of overweight and obesity almost doubled from 2002 to 2005 (21.4% and 36.8% respectively). The greatest contribution to this rapid increase in prevalence of overweight and obesity in children has come more from the children in the less wealthy districts (16.9% to 35.9%), that coupled with the previous prevalence of obese children in the wealthy areas in 2002. Boys appear to be more vulnerable to this epidemic than girls, particularly in less wealthy districts, as the proportion of boys classified as being obese in 2005 (22.5%) was three times greater than in 2002 (6.9%).

The third main finding relates to the measurement of physical activity. In an attempt to seek a valid instrument for measuring physical activity in preschool children, an integrated validation study of an existing proxy-questionnaire assessing sedentary behaviour and vigorous physical activity, was performed using an accelerometer as the criterion method. This proxy-questionnaire was demonstrated as being suitable to rank sedentary behaviour but not suitable to measure the absolute amount of time a child spends in sedentary behaviour or vigorous activity. Significant correlation coefficients were obtained for the comparison of the sum of different types of sedentary behavior and physical inactivity reported by both teacher and parents with criterion data (r = 0.29, p=0.0437 and r = 0.28, p = 0.0511 respectively). However, there was low correlation coefficients for other types of sedentary behaviour such as TV viewing (r = 0.09, p=0.5257) and vigorous activity (r = 0.15, p=0.1925) suggesting that this proxy-report approach lacks the capacity to measure different types of free-play activity in this age group of children. There was the need for more work to improve the proxy-questionnaire and the need to test it again with a validation study of improved design for use with preschool children in HCMC in the future.

Fourth, using the FFQs to measure dietary intake, an imbalance of food intake in this young child population was identified. Dietary patterns have shifted towards more energy being obtained from protein and fat, (particularly animal protein and fat) and less energy from carbohydrate, than the recommended daily intake. Most children (98.1%) had mean energy intake from protein greater than the recommendation (18%), and no child obtained energy from animal fat that was in accordance with the recommendation (<30%). Nearly one half of children (46.5%) consumed less than the advised range (60-70%) of mean energy intake from carbohydrate Such changes in food intake patterns were more pronounced in boys than in girls. Although children from higher socioeconomic levels were inclined to consume more total caloric, protein and fat than children from a lower socioeconomic status, the proportion of children with mean energy intake from protein, fat and carbohydrate exceeding the recommendation, was not significantly different between groups of different economic status.

The final main finding comes from the one year cohort study, which revealed that the aetiology of overweight and obesity in this young child population in HCMC was multi-factorial. The contextual variables of community, school and home environments, incorporated with individual characteristics, influenced the changes in adiposity and overweight and obesity development over the one year period of follow-up. There was a gender difference in the models of determinants for predicting change in adiposity and risk of developing overweight and obesity over time. At the community level, the safety of the neighbourhood area had a protective effect on weight change over time in both genders. The preschool environments, in terms of resources at preschool, such as play equipment, and the food environment around the preschool area, were shown to link with the development of overweight.

Higher socioeconomic class, the receipt of greater emotional support and cognitive stimulation from parents, were all associated with positive changes in adiposity and risk of developing overweight and obesity, although different influences were seen in boys and girls. The household wealth status and cognitive stimulation appeared to have more impact on boys, whilst emotional support appeared to be a significant factor for girls.

A good home food environment was shown to protect children from a negative weight change over the time period. This association also appeared to be more apparent in boys than in girls. The importance of parental weight status on their offspring's risk of developing overweight was underlined in this study, especially when both parents were overweight. Furthermore, maternal pre-pregnant weight status was found to have an influence on change in adiposity over time in girls but not boys. Some influence of the child's dietary intake and physical activity on their weight status, was observed. The protective effect of a longer duration of breast feeding against changes in adiposity and development of obesity was consistent, particularly in boys although the magnitude of this association was small. Food intake and physical activity patterns were found to be inconsistent risk factors across different outcomes of interest. Higher protein and carbohydrate consumption was positively associated with change in subscapular and sum of skinfold measurements in boys, and higher consumption of carbohydrates was linked with an increased risk of developing overweight in girls over time.

Children of both genders who spent more time on vigorous activity were less likely to become overweight, whilst longer duration of TV viewing elevated the risk of becoming overweight in boys. The importance of a child's characteristics on their weight change was highlighted in terms of gender and size at birth. Over the one year period of study, boys appeared to be more vulnerable to changes in adiposity than girls. Although high birth weight influenced the child's weight change, this factor was not shown to be a strong predictor for change in adiposity and development of overweight as this association was only seen for change in BMI in both genders and triceps skinfold thickness in boys.

9.2 Research strengths and limitations

This study has a number of strong points. The attendance of young children in preschools in urban areas of HCMC is high and the rate of preschool participation ranged from 80 to 100% in districts where the sample was drawn. Thus, the study was able to limit selection bias. Over the one year of follow-up, the response rate was relatively high (78.5%). The characteristics of children who participated in the follow-up and those who dropped out, were not significantly different; therefore, it is safe to conclude that the finding was representative for preschool children aged 4 to 6 years.

This cohort study provides an opportunity to examine the risk factors influencing longitudinal changes in adiposity and development of overweight and obesity that allows for the identification of the causal relationship between risk factors and outcomes. Additionally, by incorporating multiple groups of risk factors involving the contextual factors such as community, school, and home environments, and the child's characteristics, the study was able to give an explanation of the obesity development by considering the importance of the contexts and the characteristics of individuals. Using an hierarchical, conceptual framework for risk factors of obesity development, the associations between determinants and outcomes did not rely entirely on statistical significance and interpretation of the findings was in light of social and biological knowledge (Victora et al., 1997). Furthermore, potential confounders were controlled with appropriate models based on this hierarchical conceptual framework.

The measurement instruments were a weakness of this study. Information on determinants relied heavily on self-reporting, including parental BMI, pre-pregnant weight, child's birth history, food intake, and physical activity. This self-reporting might have been prone to recall bias. The questionnaires for measuring physical activity and the quality of the home environment, in terms of cognitive and emotional stimulation, were developed and validated for use in preschool children in the USA. They were not validated for children in Vietnam before being employed in this study. The integrated validation study of the proxy physical activity identified some flaws in its performance, such as underestimating the physical activity levels of children. This may have contributed to inconsistencies in the relationship between physical activity levels and the development of obesity.

9.3 Implications and recommendations

9.3.1 Implications

Since childhood obesity has not received much attention from the government, health professionals or society in Vietnam, the findings highlight the magnitude and the rapidly increasing trend of this health problem in preschool children in urban areas of HCMC. Urgent action is now required to halt this epidemic. This study has provided relatively comprehensive evidence of the determinants of development of obesity in young children that are essential for developing evidence-based prevention trials. The weaknesses of this study provide guidance for further careful evaluation to fill the gap concerning the measurement of dietary intake and physical activity and their role in childhood obesity.

9.3.2 Recommendations

At the national level, childhood obesity is not considered to be as important as malnutrition and micronutrient deficiency. There has been increased attention as a number of studies have pointed out this emerging health problem in urban populations. Since overweight and obesity has significant impact on future health outcomes of children, both in the short and long-term, the findings from this study have indicated that the need to halt the rising prevalence of childhood obesity in urban areas of HCMC, is a public health priority.

The aetiology of obesity in preschool children is multifactorial, as identified in the literature. Factors from the individual level broadening to the community level, all contribute to the development of obesity in this young child population. The next step would be to develop and implement a trial of an evidence-based prevention program using the findings from this study. Further work to fill the gap in knowledge of childhood obesity in HCMC drawn from this study should be promptly conducted. Some suggestions for further studies on childhood obesity follow.

Further assessment of parents' beliefs on the contribution of the neighbourhood environment including its physical condition, the recreation facilities available and neighbourhood safety, and of the home environment, and their effects on childhood obesity development, is needed. It is also important to know parents' perceptions and experiences of obesity in young children. These assessments would provide further insights into the context of the growing obesity problem in children in HCMC and would be useful for forming an effective prevention program in the future.

It is necessary to carry out another evaluation to assess the preschool policies on food intake and physical activity of children at preschools, using objective measures. The information is important for developing an effective preschool-based prevention program.

Finally, the assessment of dietary patterns, including foods, food groups and nutrients is necessary to provide a picture of a total diet. The information would be important for an effective dietary modification to achieve the recommendation. It is widely accepted that effective prevention programs to prevent the rising trend in childhood obesity should be multi-faceted involving children, parents, school, and the community. Based on determinants identified in this study, there are some suggestions for possible prevention trials.

At the community level, the public and policy makers should be informed of the importance of the community environment in preventing childhood obesity development. Their role is to build a neighbourhood environment that is safe and in good physical condition in an effort to increase children's physical activity.

At the preschool level, the Department of Education should be informed that the preschool environment influences young children's fitness. Preschool policy should include the building of an active play environment and the implementation of a physical education curriculum. The quality of a physical activity program in preschools may be improved by increasing the number of play equipment items, particularly gross motor play equipment, with an outdoor play area available.

At the family level, parents should be invited to participate in prevention programs. Parents should be encouraged to build a good home environment, promoting a healthy diet and encouraging physical activity for family members. The home environment quality, in terms of cognitive and emotional stimulation, should be adjusted to have a positive influence on the child's growth and development. For example, the activities stimulating the cognitive and emotional development involving sedentary behaviours, such as helping the child learn in advance the knowledge in primary school, or the rules on TV viewing and video game playing, or the number of picture books and CDs given to the child should be adjusted in terms of the duration of time and frequency and combined with other outdoor activities. Guidelines for a healthy balanced diet, food choices and a healthy home food environment should be provided. Although there were inadequate evidence supporting the association between TV viewing with the changes in the child's weight in this study, obesity prevention guidelines around the world recommends limiting TV viewing. Therefore, a physical activity-promoting home environment should encourage a reduction in sedentary behaviour such as TV and video viewing, and an increase in participation in outdoor activities with the child.

With respect to primary health care prevention, the health benefits of breast feeding and sufficient sleep, on childhood obesity development, should be confirmed with both health professionals and the community. Health professionals should encourage and support breast feeding practices. Children with a high birth weight and/or born to overweight mothers should be considered to be at higher risk for subsequent development of obesity and receive regular weight and height checks for early identification of any status change.

In conclusion, this cohort study has confirmed that an obesity epidemic has been taking place in the young child population of urban areas of HCMC. The determinants of changes in adiposity, and the development of overweight and obesity identified in this study, have significance for future action to halt this growing trend in excess weight gain in preschool children in urban areas of Ho Chi Minh City, Vietnam.

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Appendices

Appendix 1

QUESTIONNAIRES

Health Service Ho Chi Minh City
Nutrition Center

ASSESSMENT RISK FACTORS FOR EARLY ONSET OBESITY IN PRE-SCHOOL CHILDREN IN HO CHI MINH CITY, VIETNAM

ADMINISTRATION SECTION

INTRODUCTION

Good morning sir/madam, thank you very much for your coming today. We will try to process every step as fast as possible to minimize the time you spend here. Firstly, you and your child have to register at this table. Then you have 2 sites to go through (measurement, interview), we will guide you to each site. There is no required order to go to sites, we will refer you to the first available. This will help to minimize your waiting time. At each site, please keep all the sheets given to you. Finally, when you and your child have finished at all two sites, please come back here to return the data sheets and sign out. Do you have any questions?

IDENTIFICATION INFORMATION

Instruction: These questions will be completed at register table. Study number [ ][ ][ ][ ]

Q. No	Question	Response
1	Date of survey	…../……/…………..
2	District: …………………………… Code	[ ][ ]
3	School: …………………………… Code	[ ][ ]
4	Name of children Code	.... [ ][ ]
5	Gender Male Female	[ ] 1 [ ] 2
6	Month and year of birth	[ ][ ]/[ ][ ] / [ ][ ][ ][ ] dd/ mm / yyyy
7	Name of father	....
8	Month and year of birth	[ ][ ] / [ ][ ][ ][ ] mm / yyyy
9	Name of mother	....
10	Month and year of birth	[ ][ ] / [ ][ ][ ][ ] mm / yyyy
11	Home address:	....

12	Telephone number:	....		

ANTHROPOMETRIC MEASUREMENTS FOR CHILDREN

Q.No	Question	Response		
13	Height	□□□.□ cm		
14	Weight	□□.□ kg		
15	Skinfold thickness	Trial 1	Trial 2	Trial 3
	Triceps	□□.□	□□.□	□□.□
	Subscapular	□□.□	□□.□	□□.□
	Suprailiac	□□.□	□□.□	□□.□

Instruction for skinfold thickness measurement: at each site, 2 trials are required. If the results of the first 2 trials are more than 1mm or 10% (in obese subjects) in difference, then the third trial is needed.

A. CHILDREN SECTION

Let me start by asking you some questions about your child.

Q.No	Question	Response	
1	How much did *(name of child)* weigh at birth?	□□□□ grams	
2	Was (*name of child)* ever breastfed?	Yes	[ ] 1 → Q3
		No	[ ] 2 → Q4
3	How long was (*name of child)* breastfed?	□□ months	
4	How many brothers and sisters does *(name of child)* have?	□	
5	Please specify the gender and age of each by filling number	Male aged 0-5 years	[ ]
		Male aged 5-10 years	[ ]
		Male aged 11-15 years	[ ]
		Male aged 16-20 years	[ ]
		Female aged 0-5 years	[ ]
		Female aged 5-10 years	[ ]
		Female aged 11-15 years	[ ]
		Female aged 16-20 years	[ ]
6	What time does (*name of child)* usually go to bed at night?	□□(hour).□□(minute)	
7	What time does (*name of child)* usually get up in the morning?	□□(hour).□□(minute)	

B. FATHER'S SECTION

Now I would like to ask you some questions about your background.

Q.No	Question	Response	
8	What is your ethnicity?	Kinh	[ ] 1
		Hoa	[ ] 2
		Others (please specify)	…………
9	What is the highest level of school you attended?	Did not attend school	[ ] 1
		Not complete primary school	[ ] 2
		Primary school	[ ] 3
		Not complete secondary school	[ ] 4
		Secondary school	[ ] 5
		Not complete high school	[ ] 6

		High school	[ ] 7
		Academic or University	[ ] 8
10	What is your occupation?	Laborer	[ ] 1
		Trader	[ ] 2
		Skill worker	[ ] 3
		Small business person	[ ] 4
		Government officer	[ ] 5
		Teacher	[ ] 6
		Professional	[ ] 7
		Home maker	[ ] 9
		Other (please specify)	[ ] 10
		…………………………………	
11	Is this house your own property?	yes	[ ] 1
		no	[ ] 2
12	If no, do you pay rent or is it free?	rent	[ ] 1
		free	[ ] 2
13	Does your household have any of the following? (more than one items is possible) Household vehicle	Bicycle Motorcycle Car/Truck/Van Telephone Radio	( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5
	Entertainment appliances	Television Video Recorder Computer Music CD Video Game Gas Oven Rice cooker Microwave oven	( ) 6 ( ) 7 ( ) 8 ( ) 9 ( ) 10 ( ) 11 ( ) 12 ( ) 13
	Household appliances	Water pump machine Washing machine Refrigerator Air conditioner	( ) 14 ( ) 15 ( ) 16 ( ) 17

C. MOTHER'S SECTION

Now I would like to ask you some questions about your background.

Q.No	**Question**	**Response**	
14	What is your ethnicity?	Kinh	[ ] 1
		Hoa	[ ] 2
		Others (please specify)	…………
15	What is the highest level of school you attended?	Did not attend school	[ ] 1
		Not complete primary school	[ ] 2
		Primary school	[ ] 3
		Not complete secondary school	[ ] 4
		Secondary school	[ ] 5
		Not complete high school	[ ] 6

		High school	[ ] 7
		Academic or University	[ ] 8
16	What is your occupation?	Laborer	[ ] 1
		Trader	[ ] 2
		Skill worker	[ ] 3
		Small business person	[ ] 4
		Government officer	[ ] 5
		Teacher	[ ] 6
		Professional	[ ] 7
		Home maker	[ ] 9
		Other (please specify)	[ ] 10
		…………………………………	
	Now I would like to ask you some questions about your pregnant history		
17	How much did you weight before you had pregnancy of *name of child*?	□□,□kg	
18	How much did you weight just before you deliver this child?	□□,□kg	
19	How much weight did you gain in your pregnancy?	□□,□kg	
20	Were you diagnosed diabetes during this pregnancy?	Yes	[ ] 1
		No	[ ] 2
21	Was your child born at full term?	Full term birth	[ ] 1
		Premature birth	[ ] 2
		Late birth	[ ] 3
22	How long did you have the birth earlier or later than expected time?	□□weeks	

D. HOME AND NEIGHBOURHOOD ENVIRONMENTS

Q No.	Questions	Response
1	Who does the child live with?	1 2
	the child's father	[ ] Yes [ ] No
	the child's mother	[ ] Yes [ ] No
	the child's grandfather	[ ] Yes [ ] No
	the child's grandmother	[ ] Yes [ ] No
	the child's uncle	[ ] Yes [ ] No
	the child's aunt	[ ] Yes [ ] No
	the children's brothers or sisters	[ ] Yes [ ] No
	other children that not mentioned above	[ ] Yes [ ] No
	other adults that not listed above	[ ] Yes [ ] No
	Next are questions about your household and what is in you house	
6	How many square meters is your house or apartment?	………..sq. m
7	Does your child have his or her own bedroom? yes no	
8	How many TVs do you have in you house or apartment?	………...set

9	Which room in your home has a TV?	1 2
	living room	[ ] Yes [ ] No
	the child's parents 's bedroom	[ ] Yes [ ] No
	the child's bedroom	[ ] Yes [ ] No
	dinning room	[ ] Yes [ ] No
	other rooms	[ ] Yes [ ] No
10	Usually which of the following foods are stored or available in your home?	1 2
	Soft drink	[ ] Yes [ ] No
	Meat, eggs, fish	[ ] Yes [ ] No
	Biscuits or cakes	[ ] Yes [ ] No
	Milk	[ ] Yes [ ] No
	Candy, chocolate or sweets	[ ] Yes [ ] No
	Vegetables	[ ] Yes [ ] No
	Fruits	[ ] Yes [ ] No
	Ice-cream and ice-block	[ ] Yes [ ] No
	Fried food	[ ] Yes [ ] No
	Preserved fruits	[ ] Yes [ ] No
	We would like to ask you some questions about your family style and rules	
16	How often does a family member get a chance to take your child on any kind of outing (shopping, park, picnic, drive-in, and so on)?	
	A few times a year or less	1 [ ]
	About once a month	2 [ ]
	About 2 or 3 times a month	3 [ ]
	Several times a week	4 [ ]
	About once a day	5 [ ]
11	About how often do you read stories to your child?	
	Never	1 [ ]
	Several times a year	2 [ ]
	Several times a month	3 [ ]
	Once a week	4 [ ]
	At least 3 times a week	5 [ ]
	Every day	6 [ ]
12	About how many children's books does your child have?	
	None	1 [ ]
	1 or 2 books	2 [ ]
	3 to 9 books	3 [ ]
	10 or more books	4 [ ]
13		

Does your child have the use of a CD player, or tape deck, or tape recorder, or record player here at home and at least 5 children's CDs, tapes, or records? (May be shared

	with sister or brother)	
	Yes No	1 [ ] 2 [ ]
14	Which things which you (or another adult or older child) are helping or have helped your child to learn here at home (Please choose all that apply) Numbers The alphabet Colors Shapes and sizes None of the above	 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
17	Does your child have primary school preparation? Yes No	 [ ] [ ]
18	If so, how often does your child have? More than 3 times a week About 2 or 3 times a week About once a week Never	 1 [ ] 2 [ ] 3 [ ] 4 [ ]
24	How often on the average do you or other adults in your family play active game such as walking, running, jumping…with the child? once every day or more than once 3-4 times a week 1-2 times a week less than once a week	 [ ] 1 [ ] 2 [ ] 3 [ ] 4
25	On average, how many minutes each time do you or other adults in your family play active games such as walking, running, jumping… with the child?	…….. min
15	How much choice is your child allowed in deciding that foods he/she eats at breakfast and lunch? A great deal f choice Some choice Little choice No choice	 1 [ ] 2 [ ] 3 [ ] 4 [ ]
19	How often does your child eat a meal with both mother and father? More than once a day Once a day	 1 [ ] 2 [ ]

	Several times a weeks About once a week About once a month Never	3 [ ] 4 [ ] 5 [ ] 6 [ ]
35	How often does the child have pocket money? In case the child get bonus*(e.g. good performance in study or do some housework)* less than once a month 1-3 times a month 1-2 times a week 3-4 times a week 5 times per week or more	[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6
34	Does the child have pocket money? Yes No	[ ] 1 [ ] 2
36	If so, on average, how much does your child get each time?	……. VND
37	Who give the child that money? the child's parents give him or her	[ ] 1
	the child's relatives *(e.g. grandparents or uncles or aunts)*	[ ] 2
38	What is your attitude to the children buying snacks with the pocket money? the child can buy snacks with the pocket money freely the child can buy snacks with the pocket money after getting permissions the child is not allowed to buy snacks	[ ] 1 [ ] 2 [ ] 3
41	What do you feel the child play video games or watch TV? the children can do this whenever he or she wants to the child can do this after getting permission there is a rule about the time the child do this the child is not allowed to do this	[ ] 1 [ ] 2 [ ] 3 [ ] 4

6	How much time is your child away from you during an average day?	<u>During a Weekday</u>	
		Never	[ ] 1
		0-4 hours	[ ] 2
		5-8 hours	[ ] 3
		9-12 hours	[ ] 4
		>12 hours	[ ] 5
		<u>During a Weekend day</u>	

		Never	[ ] 1
		0-4 hours	[ ] 2
		5-8 hours	[ ] 3
		9-12 hours	[ ] 4
		>12 hours	[ ] 5
We would like to know about your neighborhood and what recreational resources are available for children to play.			
20	What space is available around your home which is suitable for children to play in?	1	2
	house yard	[ ] Yes	[ ] No
	Park nearby	[ ] Yes	[ ] No
	side walks	[ ] Yes	[ ] No
	lanes	[ ] Yes	[ ] No
	Other (please specify)	………………………..	
21	What is your feeling about the safety of your neighborhoods?		
	very safe and children can play without supervision	[ ] 1	
	safe but better to have supervision	[ ] 2	
	not safe but children can play with supervision	[ ] 3	
	not safe and children should not play outside	[ ] 4	
22	How does the child go to school?		
	by foot	[ ] 1	
	by bicycle	[ ] 2	
	use motorized transportation to school	[ ] 3	
23	How many minutes does it take the child to go to school?	…….. min	
26	Are there any Western fast food restaurants in the neighborhood such as McDonals, KFC, hamburgers, fish, and chip?		
	yes	[ ] 1	
	no	[ ] 2	
27	If so, how long does it take you to go to those restaurants?	…….. min	
28	Is there any local fatty food in the neighborhood such as fried cake, fried dish?		
	yes	[ ] 1	
	no	[ ] 2	
29	If so, how long does it take you to go to those restaurants?	…….. min	
30	How often does the child eat food from those restaurants?		
	less than once a month	[ ] 1	
	1-3 times a month	[ ] 2	

	1-2 times a week	[ ] 3
	3-4 times a week	[ ] 4
	5 times per week or more	[ ] 5
31	Who usually decide the child has meals at the fast food restaurants?	
	the child decides himself or herself	[ ] 1
	the child 's parents decide	[ ] 2
	the child's grandparents	[ ] 3
	decide by the whole family after discussing	[ ] 4
32	How often does the child have soft drink like Coke, Pepsi?	
	less than once a month	[ ] 1
	1-3 times a month	[ ] 2
	1-2 times a week	[ ] 3
	3-4 times a week	[ ] 4
	5 times per week or more	[ ] 5
33	How often does the child have ice-cream?	
	less than once a month	[ ] 1
	1-3 times a month	[ ] 2
	1-2 times a week	[ ] 3
	3-4 times a week	[ ] 4
	5 times per week or more	[ ] 5
39	Are there any game shops near your house or video machine at you home?	1 2
	game shops	[ ] yes [ ] No
	game machine at home	[ ] yes [ ] No
40	How often does the child go to the game shop or play games at home?	
	less than once a month	[ ] 1
	1-3/month	[ ] 2
	1-2/week	[ ] 3
	3-4/week	[ ] 4
	5 times per week or more	[ ] 5

SCHOOL ENVIRONMENT

Q No.	Questions	Response
1	How many rooms are there in your school?	…………..rooms
2	How many square meters is the school floor area?	…………...sq.m
3	Is there a playground in your school?	
	Yes	[ ] 1
	No	[ ] 2
4	How many square meters is the playground?	…………….sq.m
5	How many play equipments (for indoor and outdoor plays) are there	…………play equipments

	in your school?	
6	How many exercise sessions does your school have per day?	………..times
7	Where do exercise sessions take place? Playground Classroom	 [ ] 1 [ ] 2
8	How many minutes does one session have?	…………minutes
9	Is there any break in your school? Yes No	 [ ] 1 [ ] 2
10	If so, how many breaks does your school have?	………..times
11	Where are breaks? Playground Classroom	 [ ] 1 [ ] 2
12	Which of following activities do the child has? Free play Singing and dancing Acting Others (please specify)	 [ ] 1 [ ] 2 [ ] 3 …………………………..
13	Is there any canteen in your school? yes no	 [ ] 1 [ ] 2
14	Which of the following can students buy at the canteen? staple food (rice, noodle, bread) meat, eggs and fish vegetables and fruits milk snacks (biscuits, sweets, ice-cream) soft drink	1 2 [ ] yes [ ] No [ ] yes [ ] No [ ] yes [ ] No [ ] yes [ ] No [ ] yes [ ] No [ ] yes [ ] No
15	Does the school have any policies about kinds of foods or drinks sold in the canteen? yes no	 [ ] 1 [ ] 2
16	Does the school have any policies on students' eating snacks? Yes No	 [ ] 1 [ ] 2
17	If so, could you please talk about it? ………………………………………… ………………………………………… ………………………………………… ………………………………………… ………………………………………… …………………………………………	

18	Is there any food shop in couple hundred of meters from your school? Yes No	 [ ] 1 [ ] 2
19	If so, can you buy the things list below in the shop?	
	candies or chocolates	1 2
	biscuits or cakes fried foods preserved fruits ice-cream or ice-block jelly	[ ] yes [ ] no [ ] yes [ ] no [ ] yes [ ] no [ ] yes [ ] no [ ] yes [ ] no
20	Is there any food seller go your preschool?	[ ] yes [ ] no

E. PHYSICAL ACTIVITY AND EXERCISE FOR CHILDREN-PARENTS' REPORT

Now I would like to ask you about different types of activities your child has usually done over last three months when at home on weekdays or weekends.

Q. No	Question	Response	
1	On average, about how many hours does your child spend sitting still watching TV/video per day?	Weekday (Mon-Fri)	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
		Weekend day (Sat-Sun)	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
2	On average, about how many hours is our child involved in quiet play (such as video games, toys, dolls, readings, puzzles?) Do not include TV/Video watching or naps/sleeps.	During a Weekday	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
		During a Weekend day	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
3	On average, how many hours is your child involved in active play (such as running, jumping, climbing) that causes him/her to breath heavily or sweat?	During a Weekday	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5

		During a Weekend day	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
4	How many hours does your child have for a nap on weekends?	During a Weekend day	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
5	Where does your child usually play?	Inside the house	[ ] 1
		Front yard	[ ] 2
		Back yard	[ ] 3
		Driveway	[ ] 4
		Playground/park	[ ] 5
		Recreational centre	[ ] 6
		Other, please specify	…………….

F. PHYSICAL ACTIVITY AND EXERCISE FOR CHILDREN-TEACHER'S REPORT

Now I would like to ask you about different types of activities this child has usually done over last three months in school hours.

Q. No	Question	Response	
1	On average, about how many hours is the child involved in quiet play (such as toys, dolls, readings, painting, puzzles?)	Weekday (Mon-Fri)	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
2	On average, how many hours is the child involved in moderately active play (such as singing and dancing, sliding, cycling?)	Weekday (Mon-Fri)	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5
3	On average, how many hours is the child involved in vigorous active play (such as running, jumping, climbing) that causes him/her to breath heavily or sweat?	During a Weekday	
		None	[ ] 1
		1 hour	[ ] 2
		2 hours	[ ] 3
		3 hours	[ ] 4
		4-6 hours	[ ] 5

4	How many hours does the child have for a nap per day?	During a Weekend day None [ ] 1 1 hour [ ] 2 2 hours [ ] 3 3 hours [ ] 4 4-6 hours [ ] 5

F. FOOD FREQUENCY QUESTIONNAIRE

Instruction:

Tell the participants that the reference time is the last 3 months.

Repeat the following 2 questions for each food item in each row for each food item: "In the last 3 months, how often does (name of child) eat [food item]?" for question a on the left. "How much does (name of child) eat [food item] for one time?" for the question b on the right.

Show participants the picture of portion size of the food when the phrase "picture …" is mentioned in the question b.

Check for the completeness of the questions on each page finished.

If the answer of participants for certain question is not fit the answer options, please write down clearly the answer of participant for that food item in that row.

1	**a**	**Glutinous rice with jambon, pork pemmican, Chinese sausage.**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
2	**a**	**Glutinous rice with mungobean, black bean, maize seeds, and sugar**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
3	**a**	**Glutinous rice cake with mungobean paste or banana and sugar**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		

4	**a**	**Glutinous rice cake with mungobean paste and pork meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
5	**a**	**Mixture of pork and vegetable rolled in rice pancake, steamed**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
6	**a**	**Dumpling, filled with mixture pork and vegetable**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
7	**a**	**Bread filled with pork meat, pork meat paste, and vegetable**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	a piece
	1 [ ]	Once-twice/month	7 [ ]	1/4 loaf
	2 [ ]	3-4 times/month	8 [ ]	1/2 loaf
	3 [ ]	Once-twice/week	9 [ ]	3/4 loaf
	4 [ ]	3-4 times/week	10 [ ]	1 loaf
	5 [ ]	5-6 times/week		
8	**a**	**Pho: rice noodle with beef**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		

9	a	**Rice noodle with pork, shrimp or quail egg**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		
10	a	**Vermicelli with beef or pork or river crab past**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		
11	a	**Wheat noodle**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week k		
12	a	**Sweet bean soup (black, white, mungobean)**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		
13	a	**Sweet with sticky rice, white bean, coconut milk**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		
14	a	**Sweet soup with green bean paste**	b	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl 2 (picture)
	5 [ ]	5-6 times/week		

15	**a**	**Steamed rice**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 bowl 1 (picture)
	5 [ ]	5-6 times/week		
	6 [ ]	Everyday		
16	**a**	**Rice gruel**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 bowl 1 (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 bowl 1 (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 bowl 1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 bowl 1 (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 bowl 1 (picture)
	5 [ ]	5-6 times/week		
17	**a**	**Kinh Do bread**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 small portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 small portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 small portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 average portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 average portion (picture)
	5 [ ]	5-6 times/week		
18	**a**	**Maize (boiled, steamed, baked)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
19	**a**	**Sweet potato, Indian taro**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
20	**a**	**Cassava**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		

21	**a**	**Potato**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
22	**a**	**Tofu, fresh**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
23	**a**	**Tofu, fried**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
24	**a**	**Tofu in syrup**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 bowl (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl (picture)
	5 [ ]	5-6 times/week		
25	**a**	**Instant noodle**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
26	**a**	**Beef meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	7 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	8 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	9 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	10 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	11 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		
	6 [ ]	Everyday		

27	**a**	**Lean pork meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	7 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	8 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	9 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	10 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	11 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		
	6 [ ]	Everyday		
28	**a**	**Fat and lean pork meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	8 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		
29	**a**	**Chicken (bone removed)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	8 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		
30	**a**	**Duck meat (bone removed)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	8 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		
31	**a**	**Quail**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	Once-twice/month	7 [ ]	1 drumstick (picture)
	2 [ ]	3-4 times/month	8 [ ]	2 drumsticks (picture)
	3 [ ]	Once-twice/week	9 [ ]	1/2 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
32	**a**	**Chicken, duck liver**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soup spoon (picture)
	1 [ ]	Once-twice/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	Once-twice/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
33	**a**	**Hog liver**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)

	2 [ ]	3-4 times/month	8 [ ]	1 slice (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 slices (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 slices (picture)
	5 [ ]	5-6 times/week		
34	**a**	**Hog brain**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	3 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/4 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1/2 bowl (picture)
	5 [ ]	5-6 times/week		
35	**a**	**Chicken heart**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 slice (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 slices (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 slices (picture)
	5 [ ]	5-6 times/week		
36	**a**	**Hog heart**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week k		
37	**a**	**Lean pork paste, steamed**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 slice (picture)
	2 [ ]	3-4 times/month	8 [ ]	2 slices (picture)
	3 [ ]	1-2 times/week	9 [ ]	3 slices (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 section
	5 [ ]	5-6 times/week		
38	**a**	**Sausage**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
39	**a**	**Pork pemmican**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/2 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 soupspoon (picture)
	2 [ ]	3-4 times/month	8 [ ]	1.5 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 soupspoons (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 soupspoons (picture)
	5 [ ]	5-6 times/week		

40	**a**	**Whole milk, fresh no sugar**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	2 spoons (60ml) (picture)
	1 [ ]	1-2 times/month	7 [ ]	3 spoons (120ml) (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 cup (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
41	**a**	**Whole milk, fresh with sugar**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	2 spoons (60 ml) (picture)
	1 [ ]	1-2 times/month	7 [ ]	3 spoons (120 ml) (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 cup (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
42	**a**	**Full cream milk, powder**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	2 spoons (60 ml) (picture)
	1 [ ]	1-2 times/month	7 [ ]	3 spoons (120 ml) (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 cup (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 cup (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 cup (picture)
	5 [ ]	5-6 times/week		
43	**a**	**Skim milk, powder**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	2 spoons (60 ml) (picture)
	1 [ ]	1-2 times/month	7 [ ]	3 spoons (120 ml) (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 cup (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 cup (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 cup (picture)
	5 [ ]	5-6 times/week		
44	**a**	**Yoghurt**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portions (picture)
	5 [ ]	5-6 times/week		
45	**a**	**Condensed milk, sweetened**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 teaspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 teaspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	3 teaspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 cup (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 cup (picture)
	5 [ ]	5-6 times/week		

46	**a**	**Soy milk**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 small cup (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 cup (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/4 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 portiion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
47	**a**	**Chicken, duck egg**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 egg (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 egg (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 egg (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 egg (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 eggs (picture)
	5 [ ]	5-6 times/week		
48	**a**	**Half hatched duck-egg**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 egg (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 egg (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 egg (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 egg (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 eggs (picture)
	5 [ ]	5-6 times/week		
49	**a**	**Quail egg**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/2 egg (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 egg (picture)
	2 [ ]	3-4 times/month	8 [ ]	2-3 eggs (picture)
	3 [ ]	1-2 times/week	9 [ ]	4-5 eggs (picture)
	4 [ ]	3-4 times/week	10 [ ]	6-7eggs (picture)
	5 [ ]	5-6 times/week		
50	**a**	**Frog meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 leg (picture)
	2 [ ]	3-4 times/month	8 [ ]	2-3 legs (picture)
	3 [ ]	1-2 times/week	9 [ ]	4-5 legs (picture)
	4 [ ]	3-4 times/week	10 [ ]	6-7 legs (picture)
	5 [ ]	5-6 times/week		
51	**a**	**Eal meat**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	2 sections (picture)
	3 [ ]	1-2 times/week	9 [ ]	3 sections (picture)
	4 [ ]	3-4 times/week	10 [ ]	4 sections (picture)
	5 [ ]	5-6 times/week		
52	**a**	**Fatty fish (bong lau, basa, tra fish)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 slice (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 slice (picture)

	3 [ ]	1-2 times/week	9 [ ]	1 slice (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 slices (picture)
	5 [ ]	5-6 times/week		
53	**a**	**Fat free fish (snack-head, mackerel, anabas)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 slice (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 slice (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 slice (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 slices (picture)
	5 [ ]	5-6 times/week		
54	**a**	**Clam, oyster, helix**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1-2 clams (picture)
	1 [ ]	1-2 times/month	7 [ ]	3-4 clams (picture)
	2 [ ]	3-4 times/month	8 [ ]	5-6 clams (picture)
	3 [ ]	1-2 times/week	9 [ ]	7-8 clams (picture)
	4 [ ]	3-4 times/week	10 [ ]	9-10 clams (picture)
	5 [ ]	5-6 times/week		
55	**a**	**Prawn**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 prawn (picture)
	2 [ ]	3-4 times/month	8 [ ]	2 prawns (picture)
	3 [ ]	1-2 times/week	9 [ ]	3 prawns (picture)
	4 [ ]	3-4 times/week	10 [ ]	4 prawns (picture)
	5 [ ]	5-6 times/week		
56	**a**	**River crab**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
57	**a**	**Sea crab**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
58	**a**	**Calabash gourd, waxgourded**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 section (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 sections (picture)
	4 [ ]	3-4 times/week	10 [ ]	3 sections (picture)
	5 [ ]	5-6 times/week		

59	**a**	**Pumpkin squash**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 section (picture)
	3 [ ]	1-2 times/week	9 [ ]	2 sections (picture)
	4 [ ]	3-4 times/week	10 [ ]	4 sections (picture)
	5 [ ]	5-6 times/week		
60	**a**	**Carrot**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portions (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portions (picture)
	5 [ ]	5-6 times/week		
61	**a**	**Cabbage**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	3 soupspoons (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl (picture)
	5 [ ]	5-6 times/week		
62	**a**	**Yam bean**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/4 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	3/4 bowl (picture)
	5 [ ]	5-6 times/week		
63	**a**	**French bean**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/4 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	3/4 bowl (picture)
	5 [ ]	5-6 times/week		
64	**a**	**Mungobean sprouts**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 bowl (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl
	5 [ ]	5-6 times/week		

65	**a**	**Loofah**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 bowl (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl
	5 [ ]	5-6 times/week		
66	**a**	**Green leave vegetable**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 bowl (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 bowl
	5 [ ]	5-6 times/week		
67	**a**	**Cauliflower**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 soupspoons (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/4 bowl (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 bowl (picture)
	4 [ ]	3-4 times/week	10 [ ]	3/4 bowl (picture)
	5 [ ]	5-6 times/week		
68	**a**	**Mushroom**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 disk (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 disk (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 disk (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 disk (picture)
	5 [ ]	5-6 times/week		
69	**a**	**Grapefruit**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portions (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portions (picture)
	5 [ ]	5-6 times/week		
70	**a**	**Orange**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 section (picture)
	1 [ ]	1-2 times/month	7 [ ]	2 sections (picture)
	2 [ ]	3-4 times/month	8 [ ]	3 sections (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
71	**a**	**Mandarin**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 mandarin (picture)
	1 [ ]	1-2 times/month	7 [ ]	2-3 mandarins (picture)

	2 [ ]	3-4 times/month	8 [ ]	3 sections (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
72	**a**	**Rambutan**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 rambutan (picture)
	1 [ ]	1-2 times/month	7 [ ]	2-3 rambutans(picture)
	2 [ ]	3-4 times/month	8 [ ]	4-5 rambutans (picture)
	3 [ ]	1-2 times/week	9 [ ]	6-7 rambutants (picture)
	4 [ ]	3-4 times/week	10 [ ]	8-10 rambutans (picture)
	5 [ ]	5-6 times/week		
73	**a**	**Banana**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 banana (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 banana (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 banana (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 bananas
	5 [ ]	5-6 times/week		
74	**a**	**Pine apple**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	3/4 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1.5 portions (picture)
	5 [ ]	5-6 times/week		
75	**a**	**Papaya, ripen**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
76	**a**	**Plum**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 plum (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 plum (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 plum (picture)
	3 [ ]	1-2 times/week	9 [ ]	2-3 plums (picture)
	4 [ ]	3-4 times/week	10 [ ]	4-5 plums (picture)
	5 [ ]	5-6 times/week		
77	**a**	**Pear**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		

78	**a**	**Jackfruit**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	2-3 sections (picture)
	3 [ ]	1-2 times/week	9 [ ]	4-5 sections (picture)
	4 [ ]	3-4 times/week	10 [ ]	6-7 sections (picture)
	5 [ ]	5-6 times/week		
79	**a**	**Mangosteen**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 mangosteen (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 mangosteen (picture)
	3 [ ]	1-2 times/week	9 [ ]	2-3 mangosteens (picture)
	4 [ ]	3-4 times/week	10 [ ]	4-5 mangosteens (picture)
	5 [ ]	5-6 times/week		
80	**a**	**Red persimmon, soft type**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 red persimmon (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 red persimmon (picture)
	3 [ ]	1-2 times/week	9 [ ]	2-3 red persimmon(picture)
	4 [ ]	3-4 times/week	10 [ ]	4-5 red persimmon (picture)
	5 [ ]	5-6 times/week		
81	**a**	**Longan fruit**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	2 longans (picture)
	1 [ ]	1-2 times/month	7 [ ]	3-4 longans (picture)
	2 [ ]	3-4 times/month	8 [ ]	5-6 longans (picture)
	3 [ ]	1-2 times/week	9 [ ]	7-8 longans (picture)
	4 [ ]	3-4 times/week	10 [ ]	9-10 longans (picture)
	5 [ ]	5-6 times/week		
82	**a**	**Avocado**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
83	**a**	**Dragon’s fruit**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		

84	**a**	**Apple**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/4 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1/2 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	3/4 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 portion (picture)
	5 [ ]	5-6 times/week		
85	**a**	**Mango, ripen**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 section (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 mango (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 mango (picture)
	5 [ ]	5-6 times/week		
86	**a**	**Strawberry**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1 soupspoon (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 section (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 section (picture)
	3 [ ]	1-2 times/week	9 [ ]	1/2 mango (picture)
	4 [ ]	3-4 times/week	10 [ ]	1 mango (picture)
	5 [ ]	5-6 times/week		
87	**a**	**Biscuit (salty, sweet)**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1-2 slices (picture)
	1 [ ]	1-2 times/month	7 [ ]	3-4 slices (picture)
	2 [ ]	3-4 times/month	8 [ ]	5-6 slices (picture)
	3 [ ]	1-2 times/week	9 [ ]	7-8 slices (picture)
	4 [ ]	3-4 times/week	10 [ ]	≥ 8 slices (picture)
	5 [ ]	5-6 times/week		
88	**a**	**Flan cake**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		
89	**a**	**Chip snack**	**b**	**On average how much does the child eat?**
	0 [ ]	Never	6 [ ]	1/4 portion (picture)
	1 [ ]	1-2 times/month	7 [ ]	1/2 portion (picture)
	2 [ ]	3-4 times/month	8 [ ]	1 portion (picture)
	3 [ ]	1-2 times/week	9 [ ]	1.5 portion (picture)
	4 [ ]	3-4 times/week	10 [ ]	2 portion (picture)
	5 [ ]	5-6 times/week		

Appendix 2

The combined gender models of determinants for changes in sum and individual skinfold thickness, and development of overweight and obesity over the one year of study

Table 1 The combined gender model of risk factors predicting change in sum of skinfold thickness over the one year

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	2.53	2.29, 2.79	0.05	-1.32, 1.42	0.95
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	1.51	-0.31, 3.34	_	_	_
	Safety of environment					
	Yes	-2.77	-5.12, -0.42	-2.71	-5.07, -0.35	0.025
School environment	Amount of play equipments	0.01	-0.08, 0.11	_	_	_
	School food environment					
	Lowest	0.00				
	Medium	0.11	-2.44, 2.66	_	_	_
	Highest	1.26	-1.08, 3.59	_	_	_
	Wealth index					
Family environment	Poorest	0.00		0.00		
	Medium	1.05	-1.19, 3.29	1.63	-0.56, 3.83	0.145
	Richest	3.45	1.08, 5.82	4.33	1.86, 6.80	0.001
	Cognitive scores					
	Lowest	0.00		0.00		
	Medium	2.05	-0.27, 4.37	1.15	-1.11, 3.42	0.318
	Highest	3.70	1.39, 6.01	3.12	0.88, 5.36	0.006
	Emotional scores					
	Lowest	0.00				
	Medium	1.73	-1.78, 5.23	_	_	_
	Highest	4.10	0.49, 7.72	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-1.86	-4.17, 0.44	-2.48	-4.79, -0.83	0.034
	Highest	-3.12	-5.41, -0.83	-3.68	-5.95, -1.42	0.001
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	-0.04	-2.62, 2.54	1.64	-1.22, 4.50	0.262
	Overweight	2.45	0.04, 1.76	2.37	0.24, 4.50	0.029
	Parental BMI status					
	No parents overweight	0.00		0.00		
	Mother only overweight	0.16	-3.28, 3.59	0.62	-2.80, 4.05	0.721
	Father only overweight	2.65	0.27, 5.03	1.84	-0.38, 4.05	0.104
	Both parents overweight	5.41	2.11, 8.72	4.03	0.32, 7.74	0.033

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Father education level					
	Primary	0.00		0.00		
	Secondary	1.07	-2.44, 4.58	0.44	-3.15, 4.03	0.811
	High school	4.50	1.17, 7.83	3.34	-0.16, 6.85	0.062
	College/ University	6.07	2.52, 9.62	4.35	0.40, 8.30	0.031
Child's behaviors	Duration of breast feeding (months)	-0.16	-0.28, -0.05	-0.22	-0.33, -0.11	0.000
	Duration of sleeping (hours)	-1.28	-2.67, 0.10	_	_	_
	Energy (kcal)					
	Lowest	0.00				
	Medium	0.44	-0.27, 1.15	_	_	_
	Highest	0.17	-0.57, 0.91	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	0.001	-0.78, 0.78	_	_	_
	Highest	-0.25	-1.08, 0.58	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	0.12	-0.59, 0.82	_	_	_
	Highest	-0.29	-1.13, 0.55	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.37	-0.30, 0.39	_	_	_
	Highest	0.32	-0.52, 1.16	_	_	_
	Sedentary activity (hours)	0.10	-0.15, 0.34	_	_	_
	TV viewing (hours)	0.56	0.14, 0.99	_	_	_
	Vigorous activities (hours)	-0.64	-0.95, -0.34	_	_	_
Child's characteristics	Age (months)	0.44	0.40, 0.48	0.45	0.19, 0.70	0.001
	Gender					
	Girls	0.00		0.00		
	Boys	-0.36	-2.27, 1.56	-0.16	-2.06, 1.74	0.871
Interaction between time and gender				0.67	0.08, 1.27	0.027

Table 2 The combined gender model of risk factors predicting change in triceps skinfold thickness over the one year

Level	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	0.22	0.18, 0.26	0.20	-0.26, 0.66	0.39
Community environment	Location					
	Less wealthy districts	0.00				
	Wealthy districts	0.49	-0.08, 1.07			
	Safety of environment					
	Yes	-0.83	-1.54, -0.11	-0.81	-1.53, -0.09	0.028
School environment	Amount of play equipments	0.00	-0.04, 0.03	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	-0.21	-0.99, 0.58	_	_	_
	Highest	0.42	-0.33, 1.16	_	_	_

Level	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.37	-0.34, 1.08	0.57	-0.13, 1.27	0.11
	Wealthiest	1.07	0.32, 1.81	1.40	0.63, 2.17	0.000
	Cognitive scores					
	Lowest	0.00		0.00		
	Middle	0.53	-0.21, 1.27	0.26	-0.45, 0.97	0.472
	Highest	1.16	0.43, 1.89	0.97	0.27, 1.67	0.007
	Emotional scores					
	Lowest	0.00				
	Middle	0.22	-0.86, 1.30	_	_	_
	Highest	0.94	-0.23, 2.10	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-0.72	-1.44, -0.003	-0.92	-1.65, -0.20	0.013
	Highest	-1.02	-1.74, -0.29	-1.18	-1.90, -0.45	0.001
Parental characteristics	Parental BMI status					
	No parents overweight	0.00		0.00		
	Father only overweight	0.90	0.17, 1.63	0.64	-0.04, 1.32	0.067
	Mother only overweight	0.26	-0.91, 1.42	0.53	-0.66, 1.72	0.385
	Both parents overweight	1.72	0.82, 2.03	1.32	0.15, 2.48	0.027
	Father education level					
	Primary	0.00		0.00		
	Secondary	0.31	-0.93, 1.55	0.18	-1.05, 1.41	0.773
	High school	1.64	0.45, 2.82	1.23	0.03, 2.44	0.044
	College/ University	1.82	0.59, 3.05	1.30	-0.01, 2.61	0.053
Child's behaviours	Duration of breast feeding (months)	-0.05	-0.09, -0.02	-0.07	-0.11, -0.04	0.000
	Duration of sleeping hours	-0.35	-0.78, 0.07	_	_	_
	Energy kcal					
	Lowest	0.00				
	Middle	0.02	-0.25, 0.28	_	_	_
	Highest	0.08	-0.19, 0.34	_	_	_
	Macro-nutrients					
	Protein (g)					
	Lowest	0.00				
	Middle	0.01	-0.26, 0.28	_	_	_
	Highest	0.09	-0.19, 0.38	_	_	_

Level	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Child's behaviours	Fat (g)					
	Lowest	0.00				
	Middle	-0.07	-0.34, 0.20	_	_	_
	Highest	-0.21	-0.50, 0.09	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Middle	0.09	-0.20, 0.39	_	_	_
	Highest	0.11	-0.15, 0.38	_	_	_
Child's characteristics	Age (months)	0.04	0.03, 0.04	0.13	0.05, 0.21	0.001
	Birth weight (100 grams)	0.08	0.01, 0.15	_	_	_
	Gender					
	Girls	0.00		0.00		
	Boys	0.84	0.48, 1.19	-0.20	-0.80, 0.39	0.510
Interaction between time and gender				0.22	-0.005, 0.45	0.055

Table 3 The combined gender model of risk factors predicting change in subscapular skinfold thickness over the one year

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	0.58	0.49, 0.66	-0.01	-0.50, 0.47	0.95
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.38	-0.24, 1.01	_	_	_
	Safety of environment					
	Yes	-0.79	-1.59, 0.02	-1.06	-1.97, -0.16	0.021
School environment	Amount of play equipments	0.005	-0.03, 0.04	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	-0.18	-1.05, 0.68	_	_	_
	Highest	0.33	-0.44, 1.09	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.20	-0.54, 0.94	0.38	-0.34, 1.11	0.3
	Richest	1.11	0.31, 1.91	1.39	0.54, 2.24	0.001
	Cognitive scores					
	Lowest	0.00		0.00		
	Medium	0.56	-0.21, 1.33	0.31	-0.44, 1.06	0.418
	Highest	1.00	0.21, 1.78	0.82	0.05, 1.59	0.036
	Emotional scores					
	Lowest	0.00				
	Medium	0.22	-1.00, 1.44	_	_	_
	Highest	0.70	-0.53, 1.93	_	_	_

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-0.73	-1.51, 0.04	-0.96	-1.73, -0.18	0.016
	Highest	-1.09	-1.85, -0.32	-1.27	-2.03, -0.50	0.001
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	-0.06	-0.87, 0.75	_	_	_
	Overweight	0.83	0.08, 1.58	_	_	_
	Parental BMI status					
	No parents overweight	0.00		0.00		
	Father only overweight	0.90	0.08, 1.73	0.65	-0.12, 1.43	0.098
	Mother only overweight	-0.13	-1.12, 0.86	-0.02	-1.04, 0.99	0.964
	Both parents overweight	1.84	0.68, 3.01	1.48	0.24, 2.71	0.019
	Father education level					
	Primary	0.00		0.00		
	Secondary	0.70	-0.24, 1.64	0.68	-0.34, 1.71	0.191
	High school	1.77	0.89, 2.66	1.48	0.46, 2.51	0.005
	College/ University	2.27	1.27, 3.26	1.80	0.39, 3.21	0.012
	Paternal occupations					
	Laborer/ Street or home trader	0.00				
	Home maker/ Others	0.47	-0.69, 1.64	-0.76	-2.13, 0.62	0.282
	Small business/ Skilled workers	1.08	-1.73, 3.89	2.72	-1.03, 6.48	0.156
	Traders	1.27	0.43, 2.12	0.95	0.09, 1.81	0.031
	Government officers	1.56	0.66, 2.45	0.39	-0.72, 1.49	0.491
	Teacher/ Professionals	1.60	0.69, 2.51	0.81	-0.25, 1.87	0.136
Child's behaviours,	Duration of breast feeding months	-0.05	-0.09, -0.01	-0.06	-0.10, -0.03	0.001
	Energy (kcal)					
	Lowest	0.00		0.00		
	Medium	0.16	-0.10, 0.42	0.13	-0.14, 0.40	0.361
	Highest	0.25	0.02, 0.48	0.25	0.01, 0.49	0.039
	Protein (g)					
	Lowest	0.00		0.00		
	Medium	0.06	-0.19, 0.32	0.13	-0.14, 0.40	0.361
	Highest	0.10	-0.13, 0.34	0.25	0.01, 0.49	0.039
	Fat (g)					
	Lowest	0.00		0.00		
	Medium	-0.05	-0.27, 0.18	0.13	-0.14, 0.40	0.361
	Highest	-0.18	-0.44, 0.08	0.25	0.01, 0.49	0.039
	Carbohydrate (g)					
	Lowest	0.00		0.00		
	Medium	0.13	-0.10, 0.36	0.13	-0.14, 0.40	0.361
	Highest	0.13	-0.14, 0.39	0.25	0.01, 0.49	0.039
	Carbohydrate (g)					
	Lowest	0.00		0.00		
	Medium	0.13	-0.10, 0.36	0.13	-0.14, 0.40	0.361
	Sedentary behavior (hours)	0.01	-0.06, 0.09	_	_	_
	Vigorous activities (hours)	-0.16	-0.25, -0.07	_	_	_
	TV viewing (hours)	0.14	-0.001, 0.28	_	_	_

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Child's characteristics	Age (months)	0.10	0.09, 0.11	0.10	0.02, 0.19	0.013
	Gender					
	Girls	0.00		0.00		
	Boys	-0.12	-0.76, 0.52	-0.11	-0.75, 0.53	0.743
Interaction between gender and study time				0.26	0.06, 0.47	0.013

Table 4 The combined gender model of risk factors predicting change in suprailiac skinfold thickness over the one year

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	1.02	0.91, 1.12	0.73	-0.45, 0.64	0.730
Community environment	Location					
	Wealthy districts	0.73	0.03, 1.44	0.70	0.02, 1.40	0.034
	Less Wealthy districts	0.00		0.00		
	Safety of environment					
	Yes	-1.01	-1.91, -0.11	-1.02	-1.92, -0.12	0.027
School environment	Amount of play equipments	0.01		_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	0.41		_	_	_
	Highest	0.50		_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.43	-0.43, 1.28	0.66	-0.17, 1.49	0.121
	Richest	1.33	0.42, 2.24	1.62	0.68, 2.57	0.001
	Cognitive scores					
	Lowest	0.00		0.00		
	Middle	0.94	0.04, 1.83	0.60	-0.28, 1.48	0.179
	Highest	1.48	0.60, 2.36	1.32	0.46, 2.18	0.003
	Emotional scores					
	Lowest	0.00				
	Middle	0.71	-0.63, 2.05	_	_	_
	Highest	1.44	0.07, 2.82	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Middle	-0.54	-1.42, 0.34	-0.81	-1.69, 0.07	0.071
	Highest	-1.07	-1.95, -0.19	-1.30	-2.17, -0.42	0.004
Parental characteristics	Maternal prepregnant BMI status					
	Underweight	0.00		0.00		
	Normal	-0.04	-1.04, 0.96	0.17	-0.80, 1.15	0.730
	Overweight	0.90	0.04, 1.76	0.95	0.14, 1.77	0.022

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Parental BMI status					
	No parents overweight	0.00				
	Mother only overweight	0.06	-1.32, 1.44	_	_	_
	Father only overweight	0.88	-0.02, 1.79	_	_	_
	Both parents overweight	1.87	0.62, 3.11	_	_	_
Child's behaviors	Duration of breast feeding months	-0.06	-0.11, -0.01	-0.06	-0.11, -0.02	0.006
	Duration of sleeping (hours)	-0.59	-1.13, -0.06	_	_	_
	Energy (kcal)					
	Lowest	0.00				
	Medium	-0.003	-0.39, 0.38	_	_	_
	Highest	0.12	-0.22, 0.45	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	-0.09	-0.45, 0.28	_	_	_
	Highest	-0.37	-0.77, 0.04	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	-0.002	-0.39, 0.39	_	_	_
	Highest	0.14	-0.20, 0.47	_	_	_
	Carbohydrate (g)					
	Lowest	0.00				
	Medium	0.05	-0.30, 0.39	_	_	_
	Highest	-0.06	-0.45, 0.33	_	_	_
	Sedentary activity (hours)	0.05	-0.06, 0.17	_	_	_
	TV viewing (hours)	0.30	0.11, 0.50	_	_	_
	Vigorous activities (hours)	-0.35	-0.49, -0.21	_	_	_
Child's characteristics	Age (months)	0.18	0.16, 0.19	0.16	0.07, 0.25	0.001
	Gender					
	Girls	0.00		0.00		
	Boys	-0.09	-0.83, 0.64	-0.01	-0.74, 0.71	0.974
Interaction between gender and study time				0.88	0.36, 1.39	0.001

Table 5 The combined gender model of risk factors predicting the development of overweight (including obesity) over the one year

Levels	Predictors	Unadjusted RR	95% CI	Adjusted RR	95% CI	p-value
	Study time	1.11	1.07, 1.16	1.06	0.92, 1.23	0.297
Community environment	Resident location					
	Less wealthy districts	1.00				
	Wealthy districts	1.10	0.92, 1.30			
	Safety of environment					
	Yes	0.93	0.75, 1.14			
School environment	Amount of play equipments	1.00				
	School food environment scores					
	Lowest	1.00				
	Medium	1.03	0.81, 1.32	_	_	_
	Highest	1.13	0.91, 1.41	_	_	_

Levels	Predictors	Unadjusted RR	95% CI	Adjusted RR	95% CI	p-value
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	1.09	0.86, 1.39	1.14	0.77, 1.68	0.514
	Richest	1.51	1.22, 1.89	1.53	1.05, 2.24	0.026
	Cognitive scores					
	Lowest	1.00				
	Medium	1.13	0.90, 1.43	_	_	_
	Highest	1.22	0.97, 1.52	_	_	_
	Emotional scores					
	Lowest	0.00		0.00		
	Medium	1.16	0.80, 1.69	1.26	0.86, 1.85	0.233
	Highest	1.41	0.99, 1.20	1.47	1.01, 2.15	0.046
	Home food environment scores					
	Lowest	0.00				
	Medium	0.90	0.73, 1.11	0.71	0.50, 0.99	0.047
	Highest	0.79	0.63, 0.99	0.50	0.33, 0.76	0.001
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	1.00				
	Normal	1.15	0.88, 1.50	_	_	_
	Overweight	1.24	0.99, 1.55	_	_	_
	Parental BMI status					
	No parents overweight	0.00		0.00		
	Mother only overweight	0.93	0.64, 1.35	0.86	0.44, 1.68	0.658
	Father only overweight	1.31	1.06, 1.61	1.44	1.05, 1.98	0.024
	Both parents overweight	1.84	1.47, 2.30	1.38	0.91, 2.08	0.131
Child's behaviours	Duration of breast feeding (months)	0.99	0.98, 1.00	_	_	_
	Duration of sleeping (hours)	0.86	0.76, 0.98	_	_	_
	Energy (kcal)					
	Lowest	1.00				
	Medium	1.06	0.97, 1.15	_	_	_
	Highest	1.06	0.96, 1.17	_	_	_
	Protein (g)					
	Lowest	1.00				
	Medium	0.96	0.88, 1.05	_	_	_
	Highest	0.97	0.89, 1.06	_	_	_
	Fat (g)					
	Lowest	1.00				
	Medium	0.96	0.89, 1.04	_	_	_
	Highest	0.91	-0.39, 0.39	_	_	_
	Carbohydrate (g)					
	Lowest	1.00				
	Medium	1.04	0.96, 1.13	_	_	_
	Highest	1.07	0.98, 1.18	_	_	_
	Sedentary activity (hours)	1.02	0.99, 1.04	_	_	_
	TV viewing (hours)	1.06	1.01, 1.10	1.08	1.00, 1.16	0.045
	Vigorous activities (hours)	0.91	0.87, 0.95	0.94	0.87, 1.00	0.054

Table 6 The combined gender model of risk factors predicting the development of obesity over the one year

Levels	Predictors	Unadjusted IRR	95% CI	Adjusted IRR	95% CI	p-value
	Study time	1.04	0.97, 1.11	0.89	0.69, 1.17	0.41
Community environment	Resident location					
	Wealthy districts	1.09	0.79, 1.49			
	Less wealthy districts	0.00				
	Safety of environment					
	Yes	0.65	0.46, 0.93	0.66	0.46, 0.94	0.021
School environment	Amount of play equipments	0.99	0.98, 1.01	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	0.91	0.56, 1.48	_	_	_
	Highest	1.42	0.97, 2.08	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.94	0.61, 1.47	1.00	0.65, 1.55	0.993
	Richest	1.56	1.06, 2.30	1.54	1.05, 2.26	0.026
	Cognitive scores					
	Lowest	0.00				
	Medium	0.80	0.41, 1.57	_	_	_
	Highest	0.73	0.36, 1.48	_	_	_
	Emotional scores					
	Lowest	0.00				
	Medium	1.68	0.47, 5.98	_	_	_
	Highest	1.83	0.49, 6.89	_	_	_
	Cognitive scores					
	Lowest	0.00				
	Medium	0.80	0.41, 1.57	_	_	_
	Highest	0.73	0.36, 1.48	_	_	_
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	1.14	0.70, 1.86	_	_	_
	Overweight	1.25	0.83, 1.88	_	_	_
	Parental BMI status					
	No parents overweight	0.00		0.00		
	Mother only overweight	1.40	0.93, 2.09	1.34	0.89, 1.20	0.151
	Father only overweight	1.21	0.64, 2.29	1.27	0.68, 2.39	0.024
	Both parents overweight	2.17	1.43, 3.32	2.16	1.41, 3.32	0.000
Child's behaviours	Duration of breast feeding (months)	0.97	0.94, 0.99	0.97	0.61, 0.92	0.007
	Duration of sleeping (hours)	0.73	0.59, 0.91	0.75	0.61, 0.92	0.011

Levels	Predictors	Unadjusted IRR	95% CI	Adjusted IRR	95% CI	p-value
	Energy kcal					
Child's behaviours	Lowest	0.00				
	Medium	0.92	0.76, 1.11	_	_	_
	Highest	0.97	0.79, 1.18	_	_	_
	Protein (g)					
	Lowest	0.00				
	Medium	1.05	0.88, 1.24	_	_	_
	Highest	1.07	0.90, 1.29	_	_	_
	Fat (g)					
	Lowest	0.00				
	Medium	1.04	0.86, 1.27	_	_	_
	Highest	1.14	0.97, 1.35	_	_	_
	Carbohydrate (g)					
	Lowest	1.00				
	Medium	0.95	0.78, 1.15	_	_	_
	Highest	1.02	0.88, 1.18	_	_	_
	Sedentary activity (hours)	0.982	0.93, 1.03	_	_	_
	TV viewing hours	0.98	0.90, 1.07	_	_	_
	Vigorous activities hours	0.94	0.87, 1.02	_	_	_
Child's characteristics	Age month	1.01	0.99, 1.02	1.03	0.98, 1.07	0.252
	Gender					
	Girls	0.00		0.00		
	Boys	2.11	1.49, 2.98	2.15	1.52, 3.03	0.000
	Birth weight (100 grams)	1.04	1.02, 1.06	1.06	1.03, 1.10	0.001
Interaction between gender and study time				0.78	0.63, 0.98	0.031

Appendix 3

Univariate analysis of factors associated with changes in adiposity (BMI, skinfold thickness) in children in both genders over the one year period

Univariate analysis of factors associated with changes in BMI over the one year follow-up in girls

At the community level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Location			
Less wealthy districts	0.00		0.295
Wealthy districts	0.23	-0.20, 0.66	
Availability of play ground nearby			
Yes[1]	0.12	-0.51, 0.74	0.712
Safety of environment			
Yes[1]	-0.57	-1.15, 0.005	0.052
Game shop nearby			
Yes[1]	0.20	-0.18, 0.58	0.302
Fast food restaurant nearby			
Yes[1]	-0.29	-0.76, 0.18	0.221
Local fat food shop nearby			
Yes[1]	-0.19	-0.67, 0.28	0.422

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m2)	0.041	-0.003, 0.01	0.927
Class room size (m2)	0.003	-0.01, 0.02	0.746
Amount of play equipments	0.0005	-0.02, 0.02	0.97
School food environment scores			
Smallest	0.00		
Medium	0.36	-0.25, 0.98	0.243
Highest	0.72	0.16, 1.29	0.012

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.10	-0.41, 0.62	0.691
Richest	0.79	0.23, 1.35	0.006
Cognitive scores			
Lowest	0.00		
Middle	-0.11	-0.68, 0.46	0.705
Highest	-0.25	-0.83, 0.33	0.401
Emotional scores			
Lowest	0.00		
Middle	0.42	-0.32, 1.15	0.265
Highest	0.80	0.06, 1.55	0.034

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Having own television			
Yes[1]	0.35	-0.94, 1.65	0.590
Having game machine at home			
Yes[1]	0.17	-0.39, 0.73	0.560
Home food environment scores			
Lowest	0.00		
Middle	-0.46	-0.97, 0.05	0.079
Highest	-0.69	-1.26, -0.11	0.019

[1] *No is reference*

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.33	-0.31, 0.98	0.313
Overweight	0.68	0.18, 1.19	0.008
Parental BMI status			
No parents overweight	0.00		
Father only overweight	0.81	0.29, 1.34	0.002
Mother only overweight	0.50	-0.26, 1.25	0.198
Both parents overweight	1.66	0.83, 2.49	0.000
Father education level			
Primary	0.00		
Secondary	-0.25	-1.05, 0.54	0.533
High school	0.35	-0.37, 1.07	0.345
College/ University	0.95	0.18, 1.71	0.015
Mother education level			
Primary	0.00		
Secondary	-0.70	-1.53, 0.14	0.103
High school	-0.08	-0.90, 0.74	0.854
College/ University	0.16	-0.70, 1.02	0.712
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.37	-0.53, 1.28	0.419
Small business/ Skilled workers	-0.40	-2.18, 1.37	0.656
Traders	0.64	0.02, 1.27	0.044
Government officers	0.66	0.01, 1.31	0.048
Teacher/ Professionals	0.68	0.07, 1.29	0.028
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.75	-0.74, 2.24	0.326
Small business/ Skilled workers	0.48	-0.32, 1.28	0.242
Traders	0.27	-0.51, 1.05	0.499
Government officers	0.67	-0.18, 1.52	0.123
Teacher/ Professionals	0.33	-0.61, 1.28	0.491

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding (months)	-0.01	-0.04, 0.01	0.349
Duration of sleeping (hours)	-0.38	-0.71, -0.05	0.023
Energy kcal			
Lowest	0.00		
Medium	0.07	-0.06, 0.22	0.284
Highest	0.11	-0.02, 0.24	0.088
Protein (g)			
Lowest	0.00		
Medium	-0.08	-0.20, 0.05	0.226
Highest	-0.10	-0.24, 0.03	0.129
Energy from protein (%)			
Lowest	0.00		
Medium	-0.11	-0.27, 0.04	0.160
Highest	-0.10	-0.25, 0.05	0.185
Fat (g)			
Lowest	0.00		
Medium	-0.07	-0.19, 0.05	0.251
Highest	-0.02	-0.15, 0.12	0.789
Energy from fat (%)			
Lowest	0.00		
Medium	-0.01	-0.16, 0.15	0.946
Highest	-0.05	-0.19, 0.09	0.495
Carbohydrate (g)			
Lowest	0.00		
Medium	0.03	-0.09, 0.15	0.620
Highest	0.05	-0.09, 0.19	0.493
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	0.01	-0.12, 0.13	0.929
Highest	-0.07	-0.22, 0.07	0.335
Frequency of soft-drink consumption			
Never			
< 1/week	-0.95	-1.59, -0.32	0.003
1-3 times/week	-0.32	-0.91, 0.26	0.281
>=4 times/week	0.24	-0.37, 0.86	0.437
Frequency of ice-cream consumption			
Never			
< 1/week	-0.23	-0.94, 0.48	0.52
1-3 times/week	0.24	-0.36, 0.84	0.428
>=4 times/week	0.70	0.15, 1.26	0.012

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Frequency of Western fast food			
Never	0.00		
< 1/week	0.03	-0.43, 0.50	0.884
1-3 times/week	0.27	-0.43, 0.50	0.883
>=4 times/week	0.47	-0.37, 1.32	0.273
Frequency of local fast food			
Never	0.00		
< 1/week	0.04	-0.65, 0.72	0.911
1-3 times/week	0.27	-0.38, 0.91	0.416
>=4 times/week	0.31	-1.11, 1.73	0.671
Percentage of sedentary activity in a day			
Lowest	0.00		
Medium	-0.06	-0.19, 0.06	0.326
Highest	0.05	-0.08, 0.19	0.438
Sedentary activity (hours)	0.02	-0.02, 0.06	0.363
TV viewing (hours)	0.10	0.02, 0.17	0.011
Vigorous activities (hours)	0.001	-0.06, 0.06	0.976

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Time	0.14	0.09, 0.20	0.000
Age (months)	0.025	0.01, 0.03	0.000
Birth weight (100 grams)	0.07	0.02, 0.12	0.007
Pregnancy weight gain (kilograms)	0.05	-0.01, 0.11	0.122
Gestational diabetes			
Yes[1]	-0.24	-1.04, 0.56	0.560
Premature birth			
Yes[1]	0.28	-0.40, 0.97	0.419
Only child			
Yes[1]	-0.25	-0.69, 0.19	0.265
Birth order			
1st	0.00		
2nd	0.29	-0.22, 0.79	0.267
3rd	0.28	-0.86, 1.43	0.624
4th	-2.35	-4.02, -0.68	0.006

[1] *No is reference*

Univariate analysis of factors associated with changes in BMI over the one year follow-up in boys

At the community level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Location			
Less wealthy districts	0.00		0.737
Wealthy districts	0.09	-0.44, 0.62	
Availability of play ground nearby			
Yes[1]	0.64	-0.13, 1.41	0.105
Safety of environment			
Yes[1]	-0.50	-1.17, 0.16	0.136
Game shop nearby			
Yes[1]	0.18		0.531
Fast food restaurant nearby			
Yes[1]	0.20	-0.37, 0.78	0.490
Local fat food shop nearby			
Yes[1]	-0.45	-1.03, 0.13	0.130

[1] *No is reference*

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m2)	-0.23	-1.14, 0.68	0.620
Class room size (m2)	0.00004	-0.02, 0.02	0.996
Amount of play equipments	-0.003	-0.03, 0.03	0.853
School food environment scores			
Smallest	0.00		
Medium	-0.61	-1.31, 0.09	0.087
Highest	-0.45	-1.13, 0.22	0.185

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.10	-0.56, 0.77	0.758
Richest	0.74	0.08, 1.40	0.027
Cognitive scores			
Lowest	0.00		
Middle	0.89	0.24, 1.54	0.007
Highest	1.13	0.48, 1.78	0.001
Emotional scores			
Lowest	0.00		
Middle	0.12	-0.95, 1.19	0.825
Highest	0.70	-0.39, 1.79	0.205
Having own television			
Yes	0.24	-0.78, 1.26	0.648
No	0.00		

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Having game machine at home			
Yes	0.07	-0.47, 0.62	0.789
No	0.00		
Home food environment scores			
Lowest	0.00		
Middle	-0.19	-0.86, 0.47	0.572
Highest	-0.45	-1.09, 0.19	0.167

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.38	-0.38, 1.15	0.325
Overweight	0.44	-0.21, 1.08	0.187
Parental BMI status			
No parents overweight	0.00		
Father only overweight	0.33	-0.34, 1.01	0.335
Mother only overweight	-0.20	-1.27, 0.86	0.711
Both parents overweight	1.33	0.49, 2.18	0.002
Father education level			
Primary	0.00		
Secondary	0.87	-0.15, 1.88	0.094
High school	1.67	0.70, 2.64	0.001
College/ University	1.62	0.61, 2.63	0.002
Mother education level			
Primary	0.00		
Secondary	0.41	-0.48, 1.31	0.365
High school	0.83	-0.07, 1.73	0.07
College/ University	1.31	0.29, 2.33	0.012
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	-0.11	-1.27, 1.05	0.857
Small business/ Skilled workers	0.99	-1.52, 3.50	0.438
Traders	0.42	-0.34, 1.18	0.279
Government officers	0.58	-0.16, 1.31	0.125
Teacher/ Professionals	0.97	0.20, 1.74	0.013
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.18	-1.39, 1.76	0.818
Small business/ Skilled workers	0.41	-0.54, 1.35	0.401
Traders	0.29	-0.69, 1.27	0.567
Government officers	0.93	-0.11, 1.96	0.079
Teacher/ Professionals	0.71	-0.61, 2.02	0.292

At the child's behaviours

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding months	-0.04	-0.07, -0.005	0.025
Duration of sleeping hours	-0.32	-0.68, 0.05	0.088
Energy kcal			
Lowest	0.00		
Medium	-0.002	-0.14, 0.14	0.981
Highest	-0.02	-0.17, 0.13	0.802
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	0.15	-0.01, 0.31	0.062
Highest	0.19	0.02, 0.37	0.025
Energy from protein (%)			
Lowest	0.00		
Medium	0.02	-0.13, 0.16	0.821
Highest	0.04	-0.11, 0.19	0.576
Fat (g)			
Lowest	0.00		
Medium	0.01	-0.18, 0.19	0.942
Highest	0.12	-0.02, 0.27	0.101
Energy from fat (%)			
Lowest	0.00		
Medium	-0.01	-0.16, 0.15	0.938
Highest	0.07	-0.10, 0.23	0.417
Carbohydrate (g)			
Lowest	0.00		
Medium	-0.03	-0.18, 0.12	0.689
Highest	-0.11	-0.29, 0.07	0.234
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	-0.03	-0.16, 0.11	0.715
Highest	-0.03	-0.17, 0.12	0.716
Frequency of soft-drink consumption			
Never			
< 1/week	-0.63	-1.98, 0.72	0.363
1-3 times/week	-0.29	-1.60, 1.02	0.664
>=4 times/week	0.39	-0.93, 1.70	0.566
Frequency of ice-cream consumption			
Never			
< 1/week	-0.24	-1.20, 0.72	0.627
1-3 times/week	0.09	-0.63, 0.80	0.814
>=4 times/week	0.38	-0.29, 1.04	0.265

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Frequency of Western fast food			
Never	0.00		
< 1/week	0.21	-0.45, 0.86	0.538
1-3 times/week	0.03	-0.69, 0.74	0.938
>=4 times/week	1.01	-0.26, 2.27	0.118
Frequency of local fast food			
Never	0.00		
< 1/week	-1.11	-2.04, -0.17	0.02
1-3 times/week	0.22	-1.26, 1.69	0.775
>=4 times/week	0.38	-0.46, 1.21	0.375
Percentage of sedentary activity in a day (hours)			
Lowest	0.00		
Medium	-0.10	-0.23, 0.02	0.088
Highest	-0.09	-0.24, 0.07	0.271
Sedentary activity (hours)	-0.03	-0.08, 0.02	0.218
TV viewing (hours)	0.01	-0.08, 0.09	0.889
Vigorous activities (hours)	-0.09	-0.16, -0.02	0.007

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Time	0.29	0.22, 0.35	0.000
Age (months)	0.049	0.04, 0.06	0.000
Gender			
Girls	0.00		0.000
Boys	0.84	0.48, 1.19	
Birth weight (100 grams)	0.09	0.04, 0.15	0.002
Pregnancy weight gain (kilograms)	0.08	0.01, 0.15	0.022
Gestational diabetes			
Yes[1]	-0.78	-1.69, 0.14	0.098
Premature birth			
Yes[1]	0.13	-0.96, 1.22	0.818
Only child			
Yes[1]	0.30	-0.24, 0.85	0.275
Birth order			
1st	0.00		
2nd	-0.26	-0.86, 0.35	0.405
3rd	-0.40	-1.39, 0.58	0.420
4th	0.29	-2.02, 2.59	0.808

[1] *No is reference*

Univariate analysis of factors associated with changes in triceps skinfold thickness in girls

At the community level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Resident location			
Less wealthy districts	0.00		0.220
Wealthy districts	0.46	-0.27, 1.19	
Availability of play ground nearby			
Yes[1]	-0.08	-1.08, 0.91	0.872
Safety of environment			
Yes[1]	-0.62	-1.50, 0.27	0.173
Game shop nearby			
Yes[1]	0.25	-0.52, 1.03	0.523
Fast food restaurant nearby			
Yes[1]	-0.56	-1.34, 0.23	0.166
Local fat food shop nearby			
Yes[1]	-0.23	-1.01, 0.56	0.571

[1] *No is reference*

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m2)	-0.08	-1.38, 1.23	0.909
Class room size (m2)	0.01	-0.01, 0.04	0.369
Amount of play equipments	-0.01	-0.05, 0.023	0.470
School food environment scores			
Lowest	0.00		
Medium	0.65	-0.31, 1.60	0.183
Highest	1.26	0.28, 2.23	0.011

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.41	-0.47, 1.30	0.361
Richest	1.06	0.11, 2.01	0.029
Cognitive scores			
Lowest	0.00		
Medium	0.05	-0.91, 1.00	0.924
Highest	0.66	-0.24, 1.57	0.152

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Emotional scores			
Lowest	0.00		
Middle	1.29	0.16, 2.78	0.027
Highest	1.47	-0.23, 2.10	0.115
Having own television			
Yes	0.29	-1.54, 2.13	0.754
No	0.00		
Having game machine at home			
Yes	-0.12	-0.99, 0.75	0.786
No	0.00		
Home good food scores			
Lowest	0.00		
Medium	-0.59	-1.47, 0.29	0.193
Highest	-0.88	-1.81, 0.05	0.065

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	-0.22	-1.26, 0.83	0.681
Overweight	0.87	0.02, 1.72	0.044
Parental BMI status			
No parents overweight	0.00		
Father only overweight	1.07	0.19, 1.96	0.017
Mother only overweight	0.91	-0.49, 2.32	0.201
Both parents overweight	2.09	0.82, 3.36	0.001
Father education level			
Primary	0.00		
Secondary	-0.61	-2.05, 0.84	0.411
High school	0.75	-0.62, 2.12	0.281
College/ University	1.39	-0.03, 2.81	0.056
Mother education level			
Primary	0.00		
Secondary	-0.75	-2.06, 0.55	0.259
High school	0.54	-0.72, 1.81	0.402
College/ University	0.74	-0.61, 2.08	0.283
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.86	-0.85, 2.57	0.325
Small business/ Skilled workers	0.05	-2.59, 2.70	0.969
Traders	1.15	0.12, 2.18	0.029
Government officers	1.47	0.43, 2.52	0.006
Teacher/ Professionals	1.57	0.48, 2.66	0.005

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	1.10	-1.26, 3.47	0.361
Small business/ Skilled workers	0.51	-0.87, 1.89	0.470
Traders	0.23	-1.18, 1.63	0.751
Government officers	1.22	-0.26, 2.71	0.107
Teacher/ Professionals	0.65	-0.99, 2.29	0.438

At the child's behaviours level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding months	-0.03	-0.08, 0.01	0.157
Duration of sleeping hours	-0.25	-0.79, 0.29	0.360
Energy kcal			
Lowest	0.00		
Medium	0.07	-0.31, 0.45	0.732
Highest	-0.08	-0.44, 0.28	0.670
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	-0.02	-0.39, 0.36	0.932
Highest	-0.18	-0.54, 0.17	0.315
Energy from protein (%)			
Lowest	0.00		
Medium	-0.19	-0.58, 0.20	0.347
Highest	-0.10	-0.47, 0.26	0.578
Fat (g)			
Lowest	0.00		
Medium	-0.07	-0.42, 0.27	0.675
Highest	-0.03	-0.38, 0.32	0.864
Energy from fat (%)			
Lowest	0.00		
Medium	0.24	-0.19, 0.68	0.274
Highest	0.27	-0.12, 0.65	0.173
Carbohydrate (g)			
Lowest	0.00		
Medium	0.06	-0.29, 0.42	0.723
Highest	0.02	-0.35, 0.39	0.931
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	0.01	-0.36, 0.38	0.938
Highest	0.16	-0.19, 0.51	0.383

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Frequency of soft-drink consumption			
Never			
< 1/week	-0.22	-1.26, 0.81	0.674
1-3 times/week	0.53	-0.51, 1.58	0.318
>=4 times/week	0.79	-1.02, 2.59	0.392
Frequency of ice-cream consumption			
Never			
< 1/week	-0.15	-1.35, 1.04	0.800
1-3 times/week	0.05	-0.92, 1.02	0.915
>=4 times/week	0.48	-0.28, 1.25	0.213
Frequency of Western fast food			
Never	0.00		
< 1/week	-0.66	-2.05, 0.73	0.353
1-3 times/week	0.01	-0.80, 0.83	0.972
>=4 times/week	0.08	-1.03, 1.19	0.886
Frequency of local fast food			
Never	0.00		
< 1/week	-0.01	-1.39, 1.37	0.984
1-3 times/week	0.25	-0.91, 1.41	0.669
>=4 times/week	1.14	-0.67, 2.95	0.217
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	-0.01	-0.34, 0.32	0.974
Highest	0.15	-0.27, 0.57	0.475
Sedentary behavior (hours)	0.05	-0.07, 0.17	0.403
TV viewing (hours)	0.15	-0.05, 0.35	0.141
Vigorous activities (hours)	-0.01	-0.15, 0.14	0.913

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Time	0.79	0.64, 0.93	0.000
Age month	0.13	0.11, 0.16	0.000
Pregnancy weight gain (kilograms)	0.08	-0.01, 0.17	0.080
Birth weight (100 grams)	0.05	-0.04, 0.13	0.265
Gestational diabetes			
Yes[1]	0.68	-2.65, 4.01	0.688
Only child			
Yes[1]	-0.06	-0.82, 0.70	0.874
Birth order			
1st	0.00		
2nd	0.18	-0.67, 1.02	0.683
3rd	0.21	-1.18, 1.59	0.767
4th	-4.64	-5.73, -3.55	0.000

[1]No is reference

Univariate analysis of factors associated with change in triceps skinfold thickness over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Resident location			
Less wealthy districts	0.00		0.242
Wealthy districts	0.53	-0.36, 1.43	
Availability of play ground nearby			
Yes[1]	0.82	-0.43, 2.07	0.200
Safety of environment			
Yes[1]	-1.01	-2.2, 0.14	0.084
Game shop nearby			
Yes[1]	-0.01	-1.00, 0.98	0.984
Fast food restaurant nearby			
Yes[1]	0.26	-0.73, 1.26	0.603
Local fat food shop nearby			
Yes[1]	-0.53	-1.53, 0.48	0.303

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard	-0.67	-2.21, 0.88	0.397
Class room size (m2)	0.01	-0.02, 0.04	0.520
Amount of play equipments	0.005	-0.04, 0.05	0.857
School food environment scores			
Lowest	0.00		
Medium	-1.01	-2.27, 0.24	0.113
Highest	-0.36	-1.51, 0.79	0.545

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.31	-0.83, 1.46	0.594
Richest	1.04	-0.09, 2.17	0.072
Cognitive scores			
Lowest	0.00		
Medium	0.98	-0.14, 2.10	0.087
Highest	1.72	0.57, 2.88	0.004
Emotional scores			
Lowest	0.00		
Middle	-0.47	-2.31, 1.36	0.612
Highest	0.49	-1.47, 2.46	0.622

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Having own television			
Yes[1]	1.98	-0.40, 4.36	0.103
Having game machine at home			
Yes[1]	0.50	-0.48, 1.48	0.316
Home good food scores			
Lowest	0.00		
Medium	-0.75	-1.88, 0.39	0.199
Highest	-1.11	-2.24, 0.02	0.054

[1] *No is reference*

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.36	-0.98, 1.71	0.595
Overweight	0.53	-0.57, 1.62	0.345
Parental BMI status			
No parents overweight	0.00		
Father only overweight	0.67	-0.50, 1.85	0.262
Mother only overweight	-0.62	-2.55, 1.31	0.527
Both parents overweight	1.42	-0.29, 3.13	0.104
Father education level			
Primary	0.00		
Secondary	1.46	-0.71, 3.63	0.187
High school	2.70	0.59, 4.80	0.281
College/ University	2.49	0.35, 4.65	0.023
Mother education level			
Primary	0.00		
Secondary	0.34	-1.33, 1.99	0.693
High school	1.10	-0.53, 2.74	0.185
College/ University	1.82	-0.01, 3.64	0.051
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	-0.24	-1.95, 1.47	0.784
Small business/ Skilled workers	2.24	-2.33, 6.81	0.336
Traders	0.81	-0.53, 2.16	0.237
Government officers	0.93	-0.28, 2.15	0.131
Teacher/ Professionals	1.40	0.05, 2.75	0.042
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.61	-2.22, 3.44	0.673
Small business/ Skilled workers	1.43	-0.26, 3.13	0.098
Traders	1.30	-0.44, 3.04	0.143
Government officers	1.87	0.04, 3.69	0.045
Teacher/ Professionals	1.77	-0.40, 3.94	0.110

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding months	-0.08	-0.14, -0.02	0.006
Duration of sleeping hours	-0.45	-1.11, 0.21	0.186
Energy kcal			
Lowest	0.00		
Medium	0.10	-0.27, 0.46	0.609
Highest	0.11	-0.28, 0.51	0.577
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	0.22	-0.19, 0.64	0.299
Highest	0.20	-0.23, 0.63	0.356
Energy from protein (%)			
Lowest	0.00		
Medium	-0.06	-0.46, 0.34	0.763
Highest	0.10	-0.27, 0.46	0.606
Fat (g)			
Lowest	0.00		
Medium	-0.05	-0.47, 0.37	0.806
Highest	-0.39	-0.87, 0.08	0.107
Energy from fat (%)			
Lowest	0.00		
Medium	-0.08	-0.52, 0.37	0.729
Highest	-0.13	-0.54, 0.28	0.528
Carbohydrate (g)			
Lowest	0.00		
Medium	0.16	-0.22, 0.54	0.404
Highest	0.17	-0.29, 0.64	0.467
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	-0.06	-0.47, 0.35	0.786
Highest	-0.18	-0.53, 0.17	0.308
Frequency of soft drink consumption			
Never	0.00		
< 1/week	-1.27	-2.55, 0.005	0.051
1-3 times/week	-0.60	-1.79, 0.60	0.329
>=4 times/week	0.19	-1.62, 1.99	0.841
Frequency of ice cream consumption			
Never			
< 1/week	-0.90	-2.46, 0.65	0.254
1-3 times/week	-0.21	-1.43, 0.99	0.728
>=4 times/week	0.04	-1.17, 1.25	0.948
Frequency of Western fast food			
Never	0.00		
< 1/week	0.02	-1.16, 1.20	0.973
1-3 times/week	0.18	-1.11, 1.46	0.79
>=4 times/week	1.85	-0.06, 3.75	0.058

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Frequency of local fast food			
Never	0.00		
< 1/week	-0.75	-1.80, 0.30	0.162
1-3 times/week	-0.06	-2.00, 1.89	0.953
>=4 times/week	0.85	-0.76, 2.45	0.301
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	0.10	-0.27, 0.48	0.593
Highest	0.17	-0.31, 0.64	0.493
Sedentary behavior (hours)	0.02	-0.13, 0.16	0.804
TV viewing (hours)	-0.30	-0.47, -0.13	0.000
Vigorous activities (hours)	0.11	-0.14, 0.36	0.392

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Time	0.99	0.83, 1.15	0.000
Age month	0.17	0.14, 0.20	0.000
Pregnancy weight gain (kilograms)	0.10	-0.02, 0.23	0.098
Birth weight (100 grams)	0.13	0.02, 0.23	0.018
Gestational diabetes			
Yes	-1.55	-3.14, 0.04	0.057
Only child			
Yes	0.46	-0.49, 1.40	0.343
Birth order			
1st	0.00		
2nd	-0.56	-2.35, 1.42	0.628
3rd	-0.47	-2.35, 1.42	0.628
4th	0.79	-3.61, 5.19	0.724

[1] *No is reference*

Univariate analysis of factors associated with changes in subscapular skinfold thickness over the one year of follow-up in girls

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Community environment			
Location			
Less wealthy districts	0.00		
Wealthy districts	0.13	-0.66, 0.93	0.741
Availability of play ground nearby			
Yes[1]	0.17	-0.89, 1.22	0.759
Safety of environment			
Yes[1]	-0.69	-1.80, 0.43	0.228
Game shop nearby			
Yes[1]	0.32	-0.56, 1.20	0.477
Fast food restaurant nearby			
Yes[1]	-0.63	-1.44, 0.19	0.131
Local fast food shop nearby			
Yes[1]	-0.50	-1.36, 0.36	0.258

[1] *No is reference*

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m2)	0.27	-0.85, 1.40	0.635
Room size (m2)	0.01	-0.02, 0.04	0.448
Amount of play equipments	-0.003	-0.04, 0.03	0.866
School food environment scores			
Lowest	0.00		
Medium	0.79	-0.35, 1.93	0.174
Highest	1.42	0.39, 2.45	0.007

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.59	-0.32, 1.51	0.205
Richest	1.33	0.29, 2.36	0.012
Cognitive scores			
Lowest	0.00		
Medium	0.13	-0.91, 1.17	0.806
Highest	0.37	-0.63, 1.38	0.468
Emotional scores			
Lowest	0.00		
Medium	0.96	-0.44, 2.35	0.178
Highest	1.20	-0.41, 2.80	0.143

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Having own television			
Yes	0.73	-1.70, 3.15	0.558
Having game machine at home			
Yes	0.13	-0.90, 1.16	0.805
Home food environment scores			
Lowest	0.00		
Medium	-0.68	-1.69, 0.33	0.186
Highest	-0.98	-1.97, 0.003	0.051

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	-0.13	-1.13, 0.87	0.797
Overweight	1.14	0.20, 2.08	0.018
Parental BMI status			
No parents overweight	0.00		
Father only overweight	0.79	-0.23, 1.82	0.128
Mother only overweight	0.28	-0.99, 1.55	0.665
Both parents overweight	2.18	0.61, 3.75	0.007
Father education level			
Primary	0.00		
Secondary	0.34	-0.80, 1.48	0.561
High school	1.26	0.21, 2.31	0.018
College/ University	2.14	0.94, 3.34	0.000
Mother education level			
Primary	0.00		
Secondary	-0.71	-2.08, 0.66	0.309
High school	0.39	-0.96, 1.75	0.57
College/ University	0.45	-0.99, 1.90	0.54
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.96	-0.82, 2.74	0.291
Small business/ Skilled workers	-0.48	-3.04, 2.08	0.714
Traders	1.53	0.45, 2.61	0.006
Government officers	1.85	0.64, 3.06	0.003
Teacher/ Professionals	1.36	0.32, 2.41	0.011
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	1.04	-1.81, 3.89	0.473
Small business/ Skilled workers	0.17	-1.55, 1.89	0.844
Traders	0.16	-1.54, 1.86	0.855
Government officers	1.27	-0.64, 3.19	0.192
Teacher/ Professionals	0.52	-1.55, 2.59	0.621

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding (months)	-0.02	-0.07, 0.03	0.468
Duration of sleeping (hours)	-0.21	-0.76, 0.34	0.459
Energy (kcal)			
Lowest	0.00		
Medium	0.17	-0.20, 0.54	0.363
Highest	0.32	0.02, 0.62	0.038
Protein (g)			
Lowest	0.00		
Medium	-0.18	-0.49, 0.14	0.273
Highest	-0.15	-0.49, 0.19	0.386
Energy from protein (%)			
Lowest	0.00		
Medium	0.05	-0.33, 0.42	0.810
Highest	-0.21	-0.55, 0.13	0.219
Fat (g)			
Lowest	0.00		
Medium	-0.20	-0.50, 0.10	0.199
Highest	-0.18	-0.52, 0.16	0.301
Energy from fat (%)			
Lowest	0.00		
Medium	0.04	-0.35, 0.44	0.826
Highest	0.23	-0.24, 0.70	0.335
Carbohydrate (g)			
Lowest	0.00		
Medium	0.05	-0.22, 0.32	0.736 8
Highest	0.21	-0.14, 0.56	0.242
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	0.11	-0.22, 0.45	0.509
Highest	-0.18	-0.54, 0.18	0.317
Frequency of soft drink consumption			
Never			
< 1/week	-0.09	-1.20, 1.03	0.880
1-3 times/week	0.15	-0.10, 0.39	0.244
>=4 times/week	0.89	-0.30, 2.09	0.141
Frequency of ice cream consumption			
Never			
< 1/week	-0.29	-1.59, 1.01	0.665
1-3 times/week	0.41	-0.68, 1.49	0.461
>=4 times/week	1.31	0.31, 2.32	0.010
Frequency of Western fast food			
Never	0.00		
< 1/week	-0.64	-2.21, 0.94	0.428
1-3 times/week	-0.56	-1.53, 0.40	0.253
>=4 times/week	0.31	-0.90, 1.52	0.615
Frequency of local fast food			
Never	0.00		
< 1/week	0.02	-1.37, 1.41	0.98
1-3 times/week	0.07	-1.96, 2.10	0.944
>=4 times/week	0.42	-0.89, 1.73	0.526

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	-0.01	-0.28, 0.26	0.946
Highest	0.26	-0.08, 0.60	0.139
Sedentary behavior (hours)	0.05	-0.05, 0.15	0.303
TV viewing (hours)	0.22	0.05, 0.40	0.013
Vigorous activities (hours)	-0.09	-0.22, 0.03	0.144

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Study time	0.44	0.30, 0.58	0.000
Age month	0.08	0.05, 0.10	0.000
Pregnancy weight gain (kilograms)	0.06	-0.04, 0.17	0.250
Birth weight (100 grams)	0.01	-0.09, 0.11	0.838
Gestational diabetes			
Yes[1]	0.01	-2.08, 2.10	0.992
Only child			
Yes[1]	-0.05	-0.88, 0.77	0.900
Birth order			
1st	0.00		
2nd	0.25	-0.72, 1.21	0.615
3rd	-0.58	-1.99, 0.84	0.424
4th	-3.68	-4.56, -2.80	0.000

[1] No is reference

Univariate analysis of factors associated with changes in subscapular skinfold thickness over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Location			
Less wealthy districts	0.00		
Wealthy districts	0.61	-0.34, 1.57	0.208
Availability of play ground nearby			
Yes[1]	0.62	-0.72, 1.95	0.365
Safety of environment			
Yes[1]	-1.01	-2.22, 0.21	0.104
Game shop nearby			
Yes+1	0.29	-0.80, 1.39	0.598
Fast food restaurant nearby			
Yes[1]	0.60	-0.46, 1.66	0.266
Local fat food shop nearby			
Yes[1]	-0.58	-1.59, 0.42	0.255

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m^2)	-0.52	-2.09, 1.04	0.510
Room size	0.01	-0.01, 0.04	0.331
Amount of play equipments	0.01	-0.04, 0.07	0.617
School food environment scores			
Lowest	0.00		
Medium	-1.31	-2.63, 0.01	0.052
Highest	-0.70	-1.88, 0.48	0.246

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	-0.23	-1.41, 0.95	0.701
Richest	0.83	-0.39, 2.05	0.183
Cognitive scores			
Lowest	0.00		
Medium	1.04	-0.09, 2.18	0.072
Highest	1.67	0.46, 2.89	0.007
Emotional scores			
Lowest	0.00		
Medium	-0.24	-2.20, 1.71	0.806
Highest	0.55	-1.51, 2.62	0.596
Having own television			
Yes[1]	1.31	-1.19, 3.81	0.303
Having game machine at home			
Yes[1]	0.30	-0.71, 1.30	0.560
Home food environment scores			
Lowest	0.00		
Medium	-0.72	-1.92, 0.48	0.242
Highest	-1.26	-2.42, -0.09	0.035

[1] No is reference

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.04	-1.24, 1.32	0.951
Overweight	0.52	-0.63, 1.68	0.373
Parental BMI status			
No parents overweight	0.00		
Father only overweight	1.04	-0.30, 2.37	0.129
Mother only overweight	-0.77	-2.34, 0.79	0.335
Both parents overweight	1.53	-0.21, 3.26	0.084

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Father education level			
Primary	0.00		
Secondary	1.19	-0.47, 2.85	0.161
High school	2.43	0.82, 4.04	0.003
College/ University	2.52	0.79, 4.24	0.004
Mother education level			
Primary	0.00		
Secondary	0.32	-1.21, 1.85	0.678
High school	1.40	-0.16, 2.95	0.078
College/ University	1.97	0.10, 3.84	0.039
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.03	-1.56, 1.61	0.975
Small business/ Skilled workers	2.35	-2.16, 6.85	0.307
Traders	1.00	-0.31, 2.31	0.135
Government officers	1.27	-0.04, 2.57	0.057
Teacher/ Professionals	1.92	0.42, 3.42	0.012
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.80	-1.72, 3.32	0.534
Small business/ Skilled workers	0.69	-0.99, 2.38	0.418
Traders	1.08	-0.71, 2.87	0.236
Government officers	1.85	-0.11, 3.81	0.065
Teacher/ Professionals	1.64	-0.76, 4.04	0.181

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding months	-0.08	-0.14, -0.02	0.007
Duration of sleeping hours	-0.47	-1.22, 0.28	0.221
Energy kcal			
Lowest	0.00		
Medium	0.15	-0.23, 0.52	0.448
Highest	0.17	-0.19, 0.53	0.350
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	0.29	-0.09, 0.67	0.137
Highest	0.41	0.06, 0.77	0.021
Energy from protein (%)			
Lowest	0.00		
Medium	-0.19	-0.58, 0.21	0.353
Highest	0.04	-0.28, 0.36	0.812

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Fat (g)			
Lowest	0.00		
Medium	0.15	-0.19, 0.49	0.390
Highest	-0.14	-0.55, 0.26	0.486
Energy from fat (%)			
Lowest	0.00		
Medium	-0.19	-0.51, 0.14	0.264
Highest	-0.10	-0.50, 0.31	0.635
Carbohydrate (g)			
Lowest	0.00		
Medium	0.03	-0.37, 0.43	0.897
Highest	0.20	-0.18, 0.58	0.294
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	0.08	-0.25, 0.40	0.645
Highest	-0.11	-0.51, 0.29	0.600
Frequency of soft-drink consumption			
Never			
< 1/week	-0.44	-1.68, 0.79	0.486
1-3 times/week	-0.73	-1.56, 0.10	0.084
>=4 times/week	-0.96	-2.54, 0.62	0.234
Frequency of ice-cream consumption			
Never			
< 1/week	0.003	-1.25, 1.26	0.996
1-3 times/week	-0.29	-1.49, 0.92	0.638
>=4 times/week	-0.07	-1.90, 1.76	0.939
Frequency of Western fast food			
Never	0.00		
< 1/week	0.30	-0.98, 1.59	0.644
1-3 times/week	-0.10	-1.32, 1.13	0.877
>=4 times/week	2.06	-0.14, 4.26	0.067
Frequency of local fast food			
Never	0.00		
< 1/week	-0.06	-2.27, 2.15	0.956
1-3 times/week	-1.28	-3.05, 0.49	0.156
>=4 times/week	0.72	-0.87, 2.30	0.375
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	0.06	-0.26, 0.38	0.716
Highest	0.01	-0.34, 0.36	0.953
Sedentary behavior (hours)	0.02	-0.13, 0.16	0.804
TV viewing (hours)	-0.30	-0.47, -0.13	0.000
Vigorous activities (hours)	0.11	-0.14, 0.36	0.392

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Study time	0.66	0.52, 0.79	0.000
Age month	0.12	0.09, 0.14	0.000
Pregnancy weight gain (kilograms)	0.11	-0.02, 0.23	0.090
Birth weight (100 grams)	0.09	-0.02, 0.20	0.092
Gestational diabetes			
Yes	-2.05	-3.34, -0.77	0.002
Only child			
Yes	0.75	-0.25, 1.74	0.140
Birth order			
1st	0.00		
2nd	-0.66	-1.67, 0.35	0.203
3rd	-0.94	-2.54, 0.67	0.254
4th	0.57	-3.82, 4.96	0.799

[1] No is reference

Univariate analysis of factors associated with changes in suprailiac skinfold thickness over the one year of follow-up in girls

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Resident location			
Wealthy districts	0.75	-0.14, 1.64	
Less wealthy districts	0.00		0.098
Availability of play ground nearby			
Yes[1]	-0.07	-1.29, 1.14	0.904
Safety of environment			
Yes[1]	-0.77	-1.92, 0.39	0.192
Game shop nearby			
Yes[1]	0.20	-0.78, 1.19	0.689
Fast food restaurant nearby			
Yes[1]	-0.48	-1.42, 0.47	0.323
Local fat food shop nearby			
Yes[1]	-0.34	-1.28, 0.61	0.488

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard (10 m2)	-0.03	-1.50, 1.45	0.973
Class room size (m2)	0.02	-0.01, 0.05	0.177
Amount of play equipments	0.01	-0.04, 0.05	0.738
School food environment scores			
Lowest	0.00		
Medium	1.48	0.35, 2.60	0.010
Highest	1.61	0.36, 2.86	0.011

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.68	-0.39, 1.75	0.215
Richest	1.43	0.28, 2.59	0.015
Cognitive scores			
Lowest	0.00		
Middle	-0.03	-1.18, 1.12	0.965
Highest	0.66	-0.47, 1.80	0.251
Emotional scores			
Lowest	0.00		
Middle	1.62	0.01, 3.24	0.049
Highest	1.84	0.25, 3.43	0.023
Having own television			
Yes[1]	0.28	-1.79, 2.36	0.788
Having game machine at home			
Yes[1]	0.06	-1.03, 1.15	0.917
Home food environment scores			
Lowest	0.00		
Middle	-0.75	-1.87, 0.37	0.192
Highest	-1.13	-2.24, -0.03	0.043

[1] *No is reference*

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.13	-1.16, 1.41	0.846
Overweight	0.92	-0.14, 1.99	0.090
Parental BMI status			
No parents overweight	0.00		
Mother only overweight	1.08	-0.02, 2.18	0.054
Father only overweight	0.68	-0.96, 2.31	0.418
Both parents overweight	2.22	0.57, 3.88	0.008
Father education level			
Primary	0.00		
Secondary	-0.77	-2.49, 0.96	0.382
High school	0.44	-1.21, 2.10	0.600
College/ University	1.60	-0.16, 3.37	0.074
Mother education level			
Primary	0.00		
Secondary	-1.39	-3.04, 0.24	0.095
High school	-0.07	-1.69, 1.55	0.932
College/ University	0.26	-1.47, 1.99	0.767

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.33	-1.34, 2.01	0.694
Small business/ Skilled workers	-0.42	-3.53, 2.69	0.792
Traders	1.26	0.05, 2.48	0.041
Government officers	2.28	0.90, 3.65	0.001
Teacher/ Professionals	1.91	0.62, 3.20	0.004
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.43	-2.35, 3.22	0.762
Small business/ Skilled workers	0.28	-1.54, 2.11	0.762
Traders	0.04	-1.79, 1.89	0.963
Government officers	1.57	-0.49, 3.62	0.136
Teacher/ Professionals	1.01	-1.21, 3.24	0.372

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding (months)	-0.05	-0.11, 0.01	0.138
Duration of sleeping (hours)	-0.52	-1.13, 0.09	0.095
Energy (kcal)			
Lowest	0.00		
Medium	0.01	-0.53, 0.56	0.960
Highest	0.21	-0.27, 0.68	0.393
Protein (g)			
Lowest	0.00		
Medium	-0.32	-0.76, 0.13	0.161
Highest	-0.63	-1.17, -0.09	0.021
Energy from protein (%)			
Lowest	0.00		
Medium	-0.12	-0.67, 0.43	0.679
Highest	-0.18	-0.69, 0.34	0.507
Fat (g)			
Lowest	0.00		
Medium	0.08	-0.34, 0.50	0.705
Highest	-0.02	-0.49, 0.46	0.943
Energy from fat (%)			
Lowest	0.00		
Medium	0.03	-0.54, 0.60	0.912
Highest	0.11	-0.41, 0.63	0.690
Carbohydrate (g)			
Lowest	0.00		
Medium	0.23	-0.19, 0.66	0.285
Highest	0.25	-0.27, 0.77	0.351
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	0.18	-0.29, 0.66	0.454
Highest	-0.06	-0.61, 0.49	0.830

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Frequency of soft-drink consumption			
Never			
< 1/week	-0.06	-1.02, 0.91	0.905
1-3 times/week	0.05	-1.23, 1.34	0.936
>=4 times/week	0.72	-0.55, 1.98	0.267
Frequency of ice-cream consumption			
Never			
< 1/week	-0.38	-1.89, 1.13	0.622
1-3 times/week	0.12	-1.08, 1.32	0.846
>=4 times/week	1.15	0.01, 2.29	0.049
Frequency of Western fast food			
Never	0.00		
< 1/week	-0.59	-1.47, 0.29	0.192
1-3 times/week	-0.63	-2.32, 1.06	0.467
>=4 times/week	-0.148	-1.49, 1.19	0.828
Frequency of local fast food			
Never	0.00		
< 1/week	-0.06	-2.27, 2.15	0.955
1-3 times/week	0.38	-1.02, 1.78	0.593
>=4 times/week	0.53	-1.13, 2.18	0.535
Percentage of sedentary activity in a day (hours)			
Lowest	0.00		
Medium	-0.03	-0.46, 0.41	0.898
Highest	0.39	-0.13, 0.92	0.139
Sedentary activity (hours)	0.08	-0.07, 0.24	0.287
TV viewing (hours)	0.39	0.13, 0.65	0.004
Vigorous activities (hours)	-0.30	-0.47, -0.13	0.001

Univariate analysis of factors associated with changes in suprailiac skinfold thickness over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Time	1.15	0.96, 1.34	0.000
Resident location			
Wealthy districts	0.59	-0.49, 1.66	0.283
Less wealthy districts	0.00		
Availability of play ground nearby			
Yes[1]	0.41	-1.26, 2.07	0.632
Safety of environment			
Yes[1]	-1.42	-2.81, -0.04	0.044
Game shop nearby			
Yes[1]	0.34	-0.92, 1.59	0.599
Fast food restaurant nearby			
Yes[1]	0.75	-0.47, 1.97	0.226
Local fat food shop nearby			
Yes[1]	0.26	-0.03, 0.55	0.036

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard	-0.68	-2.45, 1.09	0.452
Class room size	0.01	-0.02, 0.05	0.400
Amount of play equipments	0.02	-0.04, 0.08	0.53
School food environment scores			
Lowest	0.00		
Medium	-0.68	-2.03, 0.66	0.317
Highest	-0.69	-2.03, 0.66	0.317

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.24	-1.11, 1.60	0.726
Richest	1.33	0.42, 2.24	0.004
Cognitive scores			
Lowest	0.00		
Middle	1.82	0.49, 3.16	0.007
Highest	2.38	1.03, 3.73	0.001
Emotional scores			
Lowest	0.00		
Middle	0.33	-1.84, 2.49	0.767
Highest	1.18	-1.07, 3.44	0.304
Having own television			
Yes	0.78	-2.06, 3.62	0.590
No	0.00		
Having game machine at home			
Yes	0.43	-0.74, 1.59	0.472
No	0.00		
Home food environment scores			
Lowest	0.00		
Middle	-0.22	-1.58, 1.13	0.746
Highest	-0.92	-2.30, 0.46	0.191

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	-0.21	-1.74, 1.31	0.783
Overweight	0.86	-1.74, 1.31	0.783
Parental BMI status			
No parents overweight	0.00		
Mother only overweight	0.72	-0.74, 2.17	0.336
Father only overweight	-0.74	-3.06, 1.58	0.531
Both parents overweight	1.36	-0.45, 3.17	0.140

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Father education level			
Primary	0.00		
Secondary	1.52	-0.71, 3.74	0.182
High school	2.41	0.30, 4.53	0.025
College/ University	3.09	0.82, 5.37	0.008
Mother education level			
Primary	0.00		
Secondary	0.32	-1.50, 2.13	0.733
High school	1.44	-0.40, 3.28	0.126
College/ University	2.44	0.29, 4.58	0.026
Paternal occupations			
Labourer/ Street or home trader	0.00		
Home maker/ Others	-0.20	-2.14, 1.75	0.842
Small business/ Skilled workers	2.49	-2.45, 7.42	0.323
Traders	0.93	-0.55, 2.42	0.219
Government officers	1.35	-0.21, 2.90	0.090
Teacher/ Professionals	1.87	0.08, 3.67	0.041
Maternal occupations			
Labourer/ Street or home trader	0.00		
Home maker/ Others	1.29	-1.60, 4.17	0.383
Small business/ Skilled workers	1.85	0.02, 3.67	0.047
Traders	2.05	0.16, 3.95	0.034
Government officers	3.05	0.92, 5.18	0.005

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding (months)	-0.08	-0.15, -0.01	0.022
Duration of sleeping (hours)	-0.57	-1.40, 0.26	0.178
Energy kcal			
Lowest	0.00		
Medium	0.01	-0.44, 0.46	0.966
Highest	-0.04	-0.57, 0.49	0.880
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	-0.10	-0.43, 0.74	0.594
Highest	0.16	-0.43, 0.74	0.594
Energy from protein (%)			
Lowest	0.00		
Medium	-0.04	-0.55, 0.47	0.871
Highest	-0.13	-0.68, 0.42	0.646

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Fat (g)			
Lowest	0.00		
Medium	0.03	-0.61, 0.67	0.928
Highest	0.23	-0.31, 0.76	0.409
Energy from fat (%)			
Lowest	0.00		
Medium	-0.21	-0.78, 0.35	0.457
Highest	0.08	-0.47, 0.63	0.773
Carbohydrate (g)			
Lowest	0.00		
Medium	0.001	-0.49, 0.49	0.996
Highest	0.01	-0.59, 0.62	0.965
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	-0.08	-0.58, 0.41	0.748
Highest	-0.05	-0.58, 0.48	0.861
Frequency of soft-drink consumption			
Never			
< 1/week	-1.14	-2.86, 0.57	0.191
1-3 times/week	-0.94	-1.93, 0.05	0.061
>=4 times/week	-0.73	-2.15, 0.69	0.318
Frequency of ice-cream consumption			
Never			
< 1/week	-0.17	-1.62, 1.28	0.82
1-3 times/week	0.19	-1.88, 2.26	0.858
>=4 times/week	0.56	-0.85, 1.97	0.435
Frequency of Western fast food			
Never	0.00		
< 1/week	0.42	-1.03, 1.86	0.572
1-3 times/week	0.08	-1.39, 1.57	0.911
>=4 times/week	1.95	-0.57, 4.48	0.129
Frequency of local fast food			
Never	0.00		
< 1/week	-1.94	-3.67, -0.21	0.028
1-3 times/week	0.25	-1.39, 1.90	0.762
>=4 times/week	0.83	-2.24, 3.90	0.596
Percentage of sedentary activity in a day (hours)			
Lowest	0.00		
Medium	-0.06	-0.54, 0.42	0.813
Highest	0.11	-0.41, 0.64	0.673
Vigorous activities (hours)	0.03	-0.15, 0.20	0.775
Sedentary activity (hours)	0.20	-0.09, 0.50	0.179
TV viewing (hours)	-0.39	-0.61, -0.16	0.001

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Age month	0.20	0.17, 0.23	0.000
Birth weight (100 grams)	0.12	-0.01, 0.25	0.075
Pregnancy weight gain (kilograms)	0.09	-0.04, 0.23	0.170
Gestational diabetes			
Yes[1]	-1.50	-3.32, 0.30	0.102
Only child			
Yes[1]	0.94	-0.20, 2.08	0.107
Birth order			
1st	0.00		
2nd	-0.63	-1.84, 0.58	0.310
3rd	-0.70	-2.81, 1.40	0.514
4th	0.64	-3.97, 5.25	0.785

[1] No is reference

Univariate analysis of factors associated with changes in sum of skinfold thickness over the one year of follow-up in girls

At the community environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Resident location			
Less wealthy districts	0.00		0.266
Wealthy districts	1.31	-0.99, 3.61	
Availability of play ground nearby			
Yes[1]	0.002	-3.13, 3.14	0.999
Safety of environment			
Yes[1]	-2.08	-5.09, 0.93	0.175
Game shop nearby			
Yes[1]	0.79	-1.72, 3.31	0.538
Western fast food outlets nearby			
Yes[1]	-1.60	-4.05, 0.85	0.200
Local fat food shop nearby			
Yes[1]	-1.04	-3.52, 1.45	0.413

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard	0.17	-3.58, 3.93	0.928
Class room size	0.04	-0.04, 0.12	0.286
Amount of play equipments	-0.01	-0.13, 0.10	0.860
School food environment scores			
Lowest	0.00		
Medium	3.08	-0.08, 6.24	0.056
Highest	4.19	1.16, 7.22	0.007

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	1.65	-1.10, 4.40	0.241
Richest	3.82	0.82, 6.83	0.013
Cognitive scores			
Lowest	0.00		
Medium	4.28	-0.10, 8.66	0.055
Highest	4.20	0.02, 8.37	0.049
Emotional scores			
Lowest	0.00		
Medium	1.73	-1.78, 5.23	0.334
Highest	4.10	0.49, 7.72	0.026
Having own television			
Yes[1]	1.34	-4.87, 7.55	0.673
Having game machine at home			
Yes[1]	0.10	-2.77, 2.98	0.944
Home food environment scores			
Lowest	0.00		
Medium	-2.02	-4.89, 0.86	0.169
Highest	-3.00	-5.89, -0.10	0.043

[1] No is reference

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	-0.22	-3.41, 2.98	0.895
Overweight	2.95	0.23, 5.69	0.034
Parental BMI status			
No parents overweight	0.00		
Mother only overweight	1.85	-2.33, 6.02	0.386
Father only overweight	2.94	0.06, 5.81	0.045
Both parents overweight	6.49	2.26, 10.72	0.003
Father education level			
Primary school	0.00		
Secondary school	-0.97	-5.14, 3.20	0.648
High school	2.51	-1.43, 6.45	0.212
College/ University	5.17	0.98, 9.35	0.016

At the parental characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Mother education level			
Primary	0.00		
Secondary	-2.85	-6.98, 1.28	0.177
High school	0.93	-3.11, 4.98	0.651
College/ University	1.45	-2.83, 5.73	0.507
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	2.07	-2.79, 6.92	0.404
Small business/ Skilled workers	-0.86	-9.07, 7.34	0.836
Traders	3.97	0.77, 7.16	0.015
Government officers	5.61	2.17, 9.05	0.001
Teacher/ Professionals	4.84	1.58, 8.11	0.004
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	2.74	-5.05, 10.52	0.490
Small business/ Skilled workers	0.99	-3.75, 5.74	0.681
Traders	0.42	-4.35, 5.19	0.863
Government officers	4.13	-1.11, 9.37	0.123
Teacher/ Professionals	2.18	-3.52, 7.87	0.454

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding (months)	-0.10	-0.25, 0.05	0.205
Duration of sleeping (hours)	-1.28	-2.67, 0.10	0.070
Energy (kcal)			
Lowest	0.00		
Medium	0.15	-0.89, 1.19	0.776
Highest	0.58	-0.40, 1.57	0.247
Protein (g)			
Lowest	0.00		
Medium	-0.74	-1.69, 0.21	0.126
Highest	-0.74	-1.08, 0.58	0.554
Energy from protein (%)			
Lowest	0.00		
Medium	-0.32	-1.42, 0.78	0.564
Highest	-0.53	-1.54, 0.48	0.303
Fat (g)			
Lowest	0.00		
Medium	-0.14	-1.05, 0.76	0.759
Highest	-0.13	-1.14, 0.88	0.802
Energy from fat (%)			
Lowest	0.00		
Medium	0.38	-0.69, 1.45	0.492
Highest	0.48	-0.78, 1.74	0.455

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Carbohydrate (g)			
Lowest	0.00		
Medium	0.32	-0.56, 1.19	0.482
Highest	0.41	-0.66, 1.48	0.455
Energy from carbohydrate (%)			
Lowest	0.00		
Medium	-0.28	-1.36, 0.79	0.611
Highest	0.39	-0.58, 1.36	0.436
Frequency of soft-drink consumption			
Never			
< 1/week	-0.03	-2.56, 2.50	0.981
1-3 times/week	-0.24	-3.55, 3.08	0.889
>=4 times/week	2.07	-1.28, 5.43	0.227
Frequency of ice-cream consumption			
Never			
< 1/week	-0.82	-4.63, 2.98	0.672
1-3 times/week	0.56	-2.54, 3.65	0.725
>=4 times/week	3.44	0.48, 6.40	0.023
Frequency of Western fast food			
Never	0.00		
< 1/week	-2.86	-5.62, -0.11	0.042
1-3 times/week	-1.86	-6.18, 2.44	0.396
>=4 times/week	0.24	-3.31, 3.79	0.893
Frequency of local fast food			
Never	0.00		
< 1/week	0.96	-2.75, 4.67	0.612
1-3 times/week	0.53	-3.68, 4.73	0.806
>=4 times/week	1.44	-4.81, 7.68	0.652
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	-0.07	-0.94, 0.79	0.872
Highest	0.77	-0.35, 1.89	0.178
Sedentary activity (hours)	-0.38	-0.77, 0.01	0.054
TV viewing (hours)	0.18	-0.13, 0.49	0.253
Vigorous activities (hours)	0.76	0.22, 1.30	0.006

At the child's characteristic

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Study time	2.23	1.84, 2.62	0.000
Age month	0.38	0.32, 0.45	0.000
Birth weight (100 grams)	0.06	-0.23, 0.35	0.678
Pregnancy weight gain (kilograms)	0.22	-0.07, 0.51	0.136
Gestational diabetes			
Yes[1]	0.37	-7.76, 8.49	0.930
Only child			
Yes[1]	-0.11	-2.50, 2.29	0.930
Birth order			
1st	0.00		
2nd	0.73	-1.99, 3.46	0.599
3rd	-0.90	-5.17, 3.37	0.680
4th	-12.60	-14.09, -11.11	0.000

[1] No is reference

Univariate analysis of factors associated with changes in sum of skinfold thickness over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Coefficients	95%CI	Wald's test p-value
Time	2.53	2.29, 2.79	0.000
Resident location			
Less wealthy districts	0.00		0.230
Wealthy districts	1.74	-1.10, 4.57	
Availability of play ground nearby			
Yes[1]	1.86	-2.28, 6.01	0.379
Safety of environment			
Yes[1]	-3.47	-7.11, 0.18	0.062
Game shop nearby			
Yes[1]	0.64	-2.62, 3.89	0.702
Western fast food outlets nearby			
Yes[1]	1.63	-1.56, 4.82	0.316
Local fat food shop nearby			
Yes[1]	-2.35	-5.39, 0.69	0.131

[1] No is reference

At the school environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Average size of school yard	-1.85	-6.58, 2.87	0.441
Class room size	0.04	-0.05, 0.12	0.381
Amount of play equipments	0.04	-0.12, 0.19	0.653
School food environment scores			
Lowest	0.00		
Medium	-1.73	-5.31, 1.86	0.346
Highest	-3.04	-7.06, 0.97	0.137

At the family environment level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.36	-3.22, 3.95	0.842
Richest	3.10	-0.53, 6.72	0.094
Cognitive scores			
Lowest	0.00		
Medium	3.91	0.42, 7.39	0.028
Highest	5.81	2.19, 9.43	0.002
Emotional scores			
Lowest	0.00		
Medium	-0.36	-6.14, 5.42	0.903
Highest	2.25	-3.82, 8.33	0.467
Having own television			
Yes[1]	4.07	-3.54, 11.67	0.294
Having game machine at home			
Yes[1]	1.28	-1.79, 4.34	0.415
Home food environment scores			
Lowest	0.00		
Medium	-1.67	-5.28, 1.92	0.361
Highest	-3.25	-6.82, 0.32	0.075

[1] *No is reference*

At the parental characteristic level

Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.18	-3.86, 4.23	0.929
Overweight	1.90	-1.59, 5.39	0.286
Parental BMI status			
No parents overweight	0.00		
Mother only overweight	-2.11	-7.81, 3.59	0.469
Father only overweight	2.41	-1.45, 6.27	0.221
Both parents overweight	4.26	-0.86, 9.39	0.103
Father education level			
Primary school	0.00		
Secondary school	4.16	-1.75, 10.07	0.168
High school	7.60	1.91, 13.30	0.009
College/ University	8.11	2.12, 14.10	0.008
Mother education level			
Primary school	0.00		
Secondary school	0.98	-3.90, 5.85	0.694
High school	3.96	-0.94, 8.85	0.113
College/ University	6.27	0.58, 11.95	0.031

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	-0.40	-5.53, 4.72	0.878
Small business/ Skilled workers	7.11	-6.86, 21.08	0.318
Traders	2.75	-1.26, 6.76	0.179
Government officers	3.58	-0.37, 7.53	0.075
Teacher/ Professionals	5.24	0.72, 9.76	0.023
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	2.60	-5.33, 10.53	0.520
Small business/ Skilled workers	4.03	-1.03, 9.09	0.119
Traders	4.42	-0.86, 9.70	0.101
Government officers	6.79	1.06, 12.53	0.020
Teacher/ Professionals	6.44	-0.72, 13.60	0.078

At the child's behaviour level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Duration of breast feeding months	-0.24	-0.42, -0.06	0.009
Duration of sleeping hours	-1.54	-3.72, 0.65	0.168
Energy (kcal)			
Lowest	0.00		
Medium	0.16	-0.89, 1.21	0.772
Highest	0.29	-0.74, 1.32	0.577
Protein (g)			
Lowest	0.00		
Medium	0.34	-0.91, 1.59	0.593
Highest	0.82	-0.42, 2.06	0.195
Energy from protein (%)	0.00		
Lowest			
Medium	0.09	-0.94, 1.12	0.870
Highest	-0.39	-1.51, 0.73	0.495
Fat (g)	0.00		
Lowest			
Medium	0.47	-0.63, 1.56	0.406
Highest	-0.41	-1.80, 0.99	0.568
Energy from fat (%)	0.00		
Lowest			
Medium	-0.09	-1.32, 1.13	0.883
Highest	-0.46	-1.62, 0.70	0.438
Carbohydrate (g)	0.00		
Lowest			
Medium	0.21	-1.12, 1.53	0.760
Highest	0.42	-0.64, 1.48	0.435

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Energy from carbohydrate (%)	0.00		
Lowest			
Medium	-0.16	-1.26, 0.93	0.769
Highest	-0.18	-1.14, 0.78	0.715
Frequency of soft drink consumption			
Never			
< 1/week	-4.92	-8.80, -1.03	0.013
1-3 times/week	-3.75	-8.30, 0.79	0.106
>=4 times/week	-1.77	-5.52, 1.99	0.357
Frequency of ice cream consumption			
Never			
< 1/week	-0.74	-6.08, 4.59	0.785
1-3 times/week	-0.66	-4.41, 3.09	0.729
>=4 times/week	0.62	-3.18, 4.41	0.751
Frequency of Western fast food			
Never	0.00		
< 1/week	0.73	-3.06, 4.53	0.706
1-3 times/week	0.20	-3.68, 4.08	0.919
>=4 times/week	5.76	-0.69, 12.22	0.081
Frequency of local fast food			
Never	0.00		
< 1/week	0.68	-6.34, 7.71	0.849
1-3 times/week	1.35	-1.60, 4.30	0.369
>=4 times/week	1.88	-2.84, 6.61	0.434
Percentage of sedentary activity in a day (%)			
Lowest	0.00		
Medium	0.14	-0.85, 1.12	0.787
Highest	0.35	-0.83, 1.53	0.562
Sedentary activity (hours)			
TV viewing (hours)			
Vigorous activities (hours)			

At the child's characteristic level

Factors	Unadjusted Coefficients	95% CI	Wald's test p-value
Study time	2.80	2.39, 3.21	0.000
Age month	0.49	0.42, 0.56	0.000
Birth weight (100 grams)	0.34	0.01, 0.67	0.046
Pregnancy weight gain (kilograms)	0.31	-0.06, 0.69	0.103
Gestational diabetes	1.10	-0.26, 2.45	0.133
Yes	-3.34	-8.07, 1.39	0.167
Only child			
Yes	2.10	-0.83, 5.15	0.157
Birth order			
1st	0.00		
2nd	-1.88	-5.05, 1.30	0.247
3rd	-2.17	-7.61, 3.25	0.433
4th	1.85	-11.47, 15.16	0.786

[1] No is reference

Univariate analysis of factors associated with development of overweight (including obesity) over the one year of follow-up in girls

At the community environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Time	1.11	1.07, 1.16	0.000
Resident location			
Less wealthy districts	1.00		
Wealthy districts	1.25	0.96, 1.63	0.098
Availability of play ground nearby			
Yes[1]	1.04	0.72, 1.50	0.834
Safety of environment			
Yes[1]	0.91	0.66, 1.26	0.581
Game shop nearby			
Yes[1]	1.04	0.76, 1.42	0.803
Fast food restaurant nearby			
Yes[1]	0.86	0.63, 1.17	0.329
Local fat food shop nearby			
Yes[1]	1.11	0.83, 1.48	0.484

[1] *No is reference*

At the school environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Average square meter of school yard	1.03	0.64, 1.64	0.914
Class room size	1.002	0.99, 1.01	0.59
Amount of play equipments	1.002	0.99, 1.02	0.779
School food environment scores			
Lowest	1.00		
Medium	1.28	0.88, 1.85	0.198
Highest	1.30	0.97, 1.91	0.076

At the family environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Wealth index			
Poorest	1.00		
Medium	1.22	0.84, 1.78	0.291
Richest	1.78	01.25, 2.53	0.001
Cognitive scores			
Lowest	1.00		
Medium	1.00	0.72, 1.39	0.992
Highest	0.94	0.66, 1.34	0.750
Emotional scores			
Lowest	1.00		
Medium	1.08	0.60, 1.95	0.786
Highest	1.49	0.89, 2.48	0.128

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Having own television			
Yes[1]	0.92	0.48, 1.75	0.797
Having game machine at home			
Yes[1]	0.91	0.66, 1.26	0.588
Home food environment scores			
Lowest	1.00		
Medium	0.76	0.55, 1.06	0.104
Highest	0.67	0.47, 0.96	0.028

[1] *No is reference*

At the parental characteristic level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	1.00		
Normal	1.23	0.81, 1.87	0.333
Overweight	1.43	1.01, 2.03	0.043
Parental BMI status			
No parents overweight	1.00		
Mother only overweight	1.17	0.69, 1.98	0.571
Father only overweight	1.64	1.17, 2.29	0.004
Both parents overweight	2.29	1.59, 3.29	0.000
Father education level			
Primary school	1.00		
Secondary school	0.95	0.49, 1.87	0.892
High school	1.39	0.77, 2.55	0.273
College/ University	1.85	1.01, 3.37	0.046
Mother education level			
Primary	1.00		
Secondary	0.72	0.43, 1.21	0.215
High school	1.05	0.66, 1.66	0.835
College/ University	1.21	0.74, 1.97	0.444
Paternal occupations			
Laborer/ Street or home trader	1.00		
Home maker/ Others	1.01	0.46, 2.21	0.986
Small business/ Skilled workers	1.36	0.46, 4.00	0.581
Traders	1.68	1.11, 2.52	0.014
Government officers	1.79	1.17, 2.74	0.008
Teacher/ Professionals	1.66	1.07, 2.57	0.025
Maternal occupations			
Laborer/ Street or home trader	1.00		
Home maker/ Others	1.25	0.41, 3.81	0.689
Small business/ Skilled workers	1.40	0.70, 2.79	0.346
Traders	1.35	0.68, 2.69	0.394
Government officers	1.99	1.003, 3.94	0.049
Teacher/ Professionals	1.31	0.57, 3.04	0.529

At the child's behaviour level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Duration of breast feeding (months)	1.00	0.98, 1.01	0.686
Duration of sleeping (hours)	0.80	0.66, .96	0.019
Energy (kcal)			
Lowest	1.00		
Medium	1.04	0.91, 1.19	0.592
Highest	1.08	0.94, 1.25	0.286
Macro-nutrients			
Protein (g)			
Lowest	1.00		
Medium	0.88	0.76, 1.03	0.108
Highest	0.88	0.76, 1.02	0.087
Energy from protein (%)			
Lowest	1.00		
Medium	0.93	0.79, 1.09	0.372
Highest	0.98	0.89, 1.07	0.642
Fat (g)			
Lowest	1.00		
Medium	0.89	0.77, 1.03	0.113
Highest	0.96	0.86, 1.08	0.518
Energy from fat (%)			
Lowest	1.00		
Medium	0.96	0.83, 1.12	0.615
Highest	1.08	0.92, 1.27	0.336
Carbohydrate (g)			
Lowest	1.00		
Medium	1.14	1.003, 1.28	0.045
Highest	1.16	1.00, 1.36	0.054
Energy from carbohydrate (%)			
Lowest	1.00		
Medium	0.95	0.81, 1.10	0.478
Highest	1.03	0.90, 1.18	0.650
Frequency of soft drink consumption			
Never			
< 1/week	0.49	0.26, 0.92	0.026
1-3 times/week	0.94	0.64, 1.36	0.725
>=4 times/week	1.20	0.87, 1.67	0.264
Frequency of ice cream consumption			
Never	1.00		
< 1/week	1.00	0.56, 1.77	0.991
1-3 times/week	1.16	0.79, 1.71	0.456
>=4 times/week	1.46	1.04, 2.04	0.028
Frequency of Western fast food			
Never	1.00		
< 1/week	0.67	0.44, 1.00	0.053
1-3 times/week	0.86	0.45, 1.68	0.665
>=4 times/week	1.01	0.71, 1.42	0.976

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Frequency of local fast food			
Never	1.00		
< 1/week	1.02	0.63, 1.66	0.921
1-3 times/week	1.23	0.85, 1.78	0.265
>=4 times/week	1.33	0.69, 2.57	0.399
Percentage of sedentary activity in a day (hours)			
Lowest	1.00		
Medium	0.95	0.83, 1.09	0.465
Highest	1.09	0.96, 1.23	0.204
Sedentary activity (hours)	1.03	0.99, 1.07	0.125
TV viewing (hours)	1.12	1.04, 1.21	0.002
Vigorous activities (hours)	0.91	0.85, 0.97	0.004

At the child's characteristic level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Age (months)	1.02	1.01, 1.03	0.001
Study time	1.10	1.04, 1.17	0.001
Birth weight (100 grams)	1.03	1.00, 1.07	0.055
Pregnancy weight gain (kilograms)	1.01	0.98, 1.05	0.475
Gestational diabetes			
Yes[1]	1.52	0.73, 3.20	0.266
Only child			
Yes[1]	1.02	0.77, 1.34	0.903
Birth order			
1st	1.00		
2nd	0.98	0.72, 1.32	0.873
3rd	1.09	0.58, 2.04	0.796
4th	0.0003	0.0001, 0.001	0.000

[1] No is reference

Univariate analysis of factors associated with development of overweight (including obesity) over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Time	1.11	1.07, 1.16	0.000
Resident location			
Less wealthy districts	1.00		
Wealthy districts	0.98	0.79, 1.23	0.893
Availability of play ground nearby			
Yes[1]	1.47	0.96, 2.26	0.075
Safety of environment			
Yes[1]	0.93	0.71, 1.22	0.615
Game shop nearby			
Yes[1]	1.04	0.81, 1.33	0.759
Fast food restaurant nearby			
Yes[1]	1.11	0.87, 1.40	0.397
Local fat food shop nearby			
Yes[1]	0.85	0.65, 1.10	0.214

[1] No is reference

At the school environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Average square meter of school yard	0.87	0.63, 1.22	0.423
Class room size	1.00	0.99, 1.01	0.658
Amount of play equipments	1.00	0.99, 1.01	0.875
School food environment scores			
Lowest	1.00		
Medium	0.85	0.62, 1.18	0.344
Highest	0.96	0.72, 1.27	0.771

At the family environment level

Factors	Unadjusted RR	95% CI	Wald's test p-value
Wealth index			
Poorest	1.00		
Medium	1.02	0.74, 1.41	0.890
Richest	1.33	1.01, 1.75	0.046
Cognitive scores			
Lowest	1.00		
Medium	1.30	0.96, 1.78	0.095
Highest	1.46	1.09, 1.97	0.013
Emotional scores			
Lowest	1.00		
Medium	1.22	0.73, 2.03	0.449
Highest	1.49	0.92, 2.40	0.102
Having own television			
Yes[1]	1.03	0.53, 1.99	0.932
Having game machine at home			
No[1]	1.00		
Home food environment scores			
Lowest	1.00		
Medium	1.02	0.78, 1.33	0.891
Highest	0.91	0.68, 1.23	0.544

[1] No is reference

At the parental characteristic level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	1.00		
Normal	1.12	0.79, 1.58	0.500
Overweight	1.13	0.86, 1.50	0.371
Parental BMI status			
No parents overweight	1.00		
Mother only overweight	0.82	0.47, 1.43	0.477
Father only overweight	1.15	0.87, 1.51	0.326
Both parents overweight	1.61	1.21, 2.14	0.001

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Father education level			
Primary school	1.00		
Secondary school	1.69	0.67, 4.25	0.268
High school	2.22	0.89, 5.49	0.085
College/ University	2.12	0.85, 5.32	0.109
Mother education level			
Primary school	1.00		
Secondary school	1.27	0.76, 2.14	0.36
High school	1.49	0.90, 2.48	0.121
College/ University	1.65	0.97, 2.80	0.062
Paternal occupations			
Laborer/ Street or home trader	1.00		
Home maker/ Others	1.20	0.69, 2.07	0.518
Small business/ Skilled workers	1.25	0.56, 2.82	0.584
Traders	1.20	0.85, 1.69	0.296
Government officers	1.24	0.87, 1.75	0.227
Teacher/ Professionals	1.56	1.12, 2.17	0.008
Maternal occupations			
Laborer/ Street or home trader	1.00		
Home maker/ Others	1.37	0.63, 2.97	0.423
Small business/ Skilled workers	1.33	0.78, 2.27	0.293
Traders	1.13	0.65, 1.95	0.664
Government officers	1.42	0.81, 2.50	0.215
Teacher/ Professionals	1.34	0.73, 2.45	0.349

At the child's behaviour level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Duration of breast feeding (months)	0.98	0.97, 0.99	0.045
Duration of sleeping (hours)	0.91	0.77, 1.06	0.222
Energy (kcal)			
Lowest	1.00		
Medium	1.03	0.93, 1.14	0.577
Highest	1.06	0.93, 1.21	0.383
Protein (g)			
Lowest	1.00		
Medium	1.03	0.92, 1.16	0.567
Highest	1.05	0.96, 1.16	0.299
Energy from protein (%)			
Lowest	1.00		
Medium	1.00	0.89, 1.14	0.962
Highest	1.03	0.92, 1.14	0.649

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Fat (g)			
Lowest	1.00		
Medium	0.96	0.85, 1.08	0.460
Highest	0.93	0.82, 1.05	0.230
Energy from fat (%)			
Lowest	1.00		
Medium	0.98	0.88, 1.10	0.738
Highest	1.00	0.88, 1.13	0.988
Carbohydrate (g)			
Lowest	1.00		
Medium	0.97	0.87, 1.08	0.587
Highest	1.00	0.89, 1.12	0.977
Energy from carbohydrate (%)			
Lowest	1.00		
Medium	0.98	0.87, 1.10	0.739
Highest	0.94	0.82, 1.08	0.409
Frequency of soft drink consumption			
Never			
< 1/week	0.67	0.45, 1.02	0.059
1-3 times/week	0.72	0.49, 1.05	0.090
>=4 times/week	0.84	0.64, 1.11	0.226
Frequency of ice cream consumption			
Never			
< 1/week	1.00	0.72, 1.37	0.988
1-3 times/week	1.04	0.70, 1.54	0.850
>=4 times/week	1.28	0.96, 1.70	0.088
Frequency of Western fast food			
Never	1.00		
< 1/week	0.85	0.62, 1.17	0.319
1-3 times/week	1.00	0.72, 1.40	0.987
>=4 times/week	1.24	0.86, 1.78	0.259
Frequency of local fast food			
Never	1.00		
< 1/week	0.64	0.34, 1.20	0.165
1-3 times/week	0.84	0.43, 1.64	0.602
>=4 times/week	1.15	0.83, 1.58	0.404
Percentage of sedentary activity in a day (hours)			
Lowest	1.00		
Medium	1.01	0.92, 1.12	0.780
Highest	1.03	0.93, 1.14	0.606
Sedentary activity (hours)	1.01	0.98, 1.04	0.592
TV viewing (hours)	0.90	0.84, 0.95	0.653
Vigorous activities (hours)	1.01	0.96, 1.06	0.000

At the child's characteristic level

Factors	Unadjusted RR	95% CI	Wald's test p-value
Age (months)	1.02	1.01, 1.03	0.000
Study time	1.12	1.07, 1.18	0.000
Birth weight (100 grams)	1.02	1.01, 1.06	0.004
Pregnancy weight gain (kilograms)	1.02	1.00, 1.04	0.101
Gestational diabetes			
Yes[1]	1.00	0.47, 2.10	0.993
Only child			
Yes[1]	1.12	0.89, 1.42	0.325
Birth order			
1st	1.00		
2nd	0.89	0.68, 1.17	0.408
3rd	0.87	0.51, 1.49	0.619
4th	1.47	0.77, 2.78	0.239

[1] *No is reference*

Univariate analysis of factors associated with development of obesity over the one year of follow-up in girls

At the community environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Time	0.99	0.86, 1.15	0.931
Resident location			
Less wealthy districts	0.00		
Wealthy districts	1.29	0.75, 2.23	0.364
Availability of play ground nearby			
Yes[1]	0.71	0.37, 1.36	0.296
Safety of environment			
Yes[1]	0.52	0.28, 0.95	0.032
Game shop nearby			
Yes[1]	0.82	0.42, 1.58	0.553
Fast food restaurant nearby			
Yes[1]	0.65	0.33, 1.26	0.205
Local fat food shop nearby			
Yes[1]	0.69	0.37, 1.30	0.253

[1] *No is reference*

At the school environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Average square meter of school yard	0.56	0.29, 1.10	0.090
Class room size	1.00	0.98, 1.02	0.817
Amount of play equipments	0.99	0.96, 1.01	0.290
School food environment scores			
Lowest	0.00		
Medium	1.99	0.81, 4.84	0.132
Highest	4.15	2.08, 8.28	0.000

At the family environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	1.33	0.61, 2.90	0.471
Richest	1.86	0.92, 3.79	0.086
Cognitive scores			
Lowest	0.00		
Medium	0.80	0.41, 1.57	0.517
Highest	0.73	0.36, 1.48	0.387
Emotional scores			
Lowest	0.00		
Medium	1.68	0.47, 5.98	0.427
Highest	1.83	0.49, 6.89	0.370
Having own television			
Yes[1]	1.16	0.36, 3.68	0.806
Having game machine at home			
Yes[1]	1.11	0.58, 2.10	0.754
Home food environment scores			
Lowest	0.00		
Medium	0.54	0.26, 1.13	0.101
Highest	0.61	0.31, 1.20	0.153

[1] No is reference

At the parental characteristic level

Factors	Unadjusted RR	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	1.85	0.82, 4.16	0.139
Overweight	2.08	0.85, 5.09	0.108
Parental BMI status			
No parents overweight	0.00		
Father only overweight	2.32	1.09, 4.94	0.028
Mother only overweight	1.85	0.64, 5.34	0.254
Both parents overweight	4.32	2.05, 9.14	0.000
Father education level			
Primary	0.00		
Secondary	1.15	0.34, 3.91	0.818
High school	1.23	0.39, 3.84	0.721
College/ University	1.42	0.44, 4.62	0.559
Mother education level			
Primary	0.00		
Secondary	0.54	0.22, 1.32	0.177
High school	0.61	0.26, 1.40	0.24
College/ University	0.60	0.22, 1.64	0.316

Factors	Unadjusted RR	95% CI	Wald's test p-value
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	1.18	0.33, 4.20	0.796
Small business/ Skilled workers	1.10	0.92, 1.33	0.123
Traders	1.39	0.64, 3.01	0.404
Government officers	1.27	0.53, 3.03	0.588
Teacher/ Professionals	1.15	0.45, 2.97	0.770
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	1.35	0.27, 6.71	0.714
Small business/ Skilled workers	0.98	0.29, 2.32	0.705
Traders	0.82	0.29, 2.32	0.705
Government officers	0.65	0.19, 2.25	0.492
Teacher/ Professionals	0.46	0.09, 2.40	0.356

At the child's behaviour level

Factors	Unadjusted RR	95% CI	Wald's test p-value
Duration of breast feeding (months)	0.96	0.92, 1.00	0.079
Duration of sleeping (hours)	0.75	0.53, 1.06	0.102
Energy kcal			
Lowest	0.00		
Medium	0.94	0.64, 1.37	0.748
Highest	0.94	0.57, 1.52	0.789
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	0.92	0.68, 1.23	0.571
Highest	1.07	0.74, 1.54	0.714
Energy from protein (%)			
Lowest	0.00		
Medium	0.95	0.61, 1.48	0.829
Highest	0.97	0.72, 1.32	0.854
Fat (g)			
Lowest	0.00		
Medium	1.20	0.85, 1.71	0.295
Highest	1.26	0.92, 1.71	0.148
Energy from fat (%)			
Lowest	1.00		
Medium	1.03	0.67, 1.59	0.877
Highest	1.19	0.89, 1.61	0.244
Carbohydrate (g)			
Lowest	1.00		
Medium	0.77	0.53, 1.12	0.172
Highest	0.95	0.69, 1.30	0.756

Factors	Unadjusted RR	95% CI	Wald's test p-value
Energy from carbohydrate (%)			
Lowest	1.00		
Medium	1.04	0.75, 1.44	0.803
Highest	1.03	0.62, 1.71	0.902
Frequency of soft drink consumption			
Never			
< 1/week	0.59	0.19, 1.76	0.340
1-3 times/week	0.77	0.35, 1.73	0.535
>=4 times/week	1.50	0.47, 4.74	0.490
Frequency of ice cream consumption			
Never			
< 1/week	0.52	0.15, 1.89	0.323
1-3 times/week	2.35	1.04, 5.34	0.040
>=4 times/week	2.53	1.17, 5.44	0.018
Frequency of Western fast food			
Never	0.00		
< 1/week	0.62	0.22, 1.73	0.359
1-3 times/week	0.79	0.39, 1.59	0.504
>=4 times/week	0.90	0.74, 1.10	0.303
Frequency of local fast food			
Never	0.00		
< 1/week	0.78	0.32, 1.91	0.587
1-3 times/week	1.26	0.59, 2.65	0.548
>=4 times/week	1.64	0.52, 5.21	0.401
Percentage of sedentary activity in a day			
Lowest	0.00		
Medium	0.97	0.63, 1.50	0.888
Highest	0.87	0.58, 1.29	0.496
Sedentary activity (hours)	0.94	0.83, 1.06	0.323
TV viewing (hours)	0.86	0.69, 0.99	0.114
Vigorous activities (hours)	0.83	0.71, 1.04	0.045

At the child's characteristic level

Factors	Unadjusted RR	95% CI	Wald's test p-value
Birth weight (100 grams)	1.08	1.01, 1.14	0.016
Pregnancy weight gain (kilograms)	1.00	0.93, 1.07	0.946
Gestational diabetes			
Yes	0.89	0.13, 6.04	0.906
Only child			
Yes	0.54	0.29, 1.02	0.056
Birth order			
1st	0.00		
2nd	1.48	0.82, 2.64	0.190
3rd	1.33	0.32, 5.44	0.692
4th	1.49	0.55, 4.03	0.429

[1] *No is reference*

Univariate analysis of factors associated with development of obesity over the one year of follow-up in boys

At the community environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Resident location			
Less wealthy districts	0.00		
Wealthy districts	1.01	0.69, 1.48	0.944
Availability of play ground nearby			
Yes[1]	1.27	0.66, 2.46	0.468
Safety of environment			
Yes[1]	0.73	0.48, 1.13	0.155
Game shop nearby			
Yes[1]	0.95	0.62, 1.45	0.804
Fast food restaurant nearby			
Yes[1]	1.00	0.66, 1.51	0.999
Local fat food shop nearby			
Yes[1]	0.69	0.43, 1.11	0.131

[1] *No is reference*

At the school environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Average square meter of school yard	0.92	0.51, 1.68	0.796
Class room size	1.00	0.98, 1.01	0.951
Amount of play equipments	1.00	0.97, 1.02	0.766
School food environment scores			
Lowest	0.00		
Medium	0.64	0.36, 1.14	0.129
Highest	0.82	0.51, 1.31	0.409

At the family environment level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Wealth index			
Poorest	0.00		
Medium	0.84	0.49, 1.43	0.518
Richest	1.39	0.88, 2.19	0.153
Cognitive scores			
Lowest	0.00		
Medium	1.61	0.96, 2.72	0.073
Highest	1.68	1.01, 2.81	0.048
Emotional scores			
Lowest	0.00		
Medium	0.98	0.47, 2.03	0.951
Highest	1.05	0.54, 2.06	0.882
Having own television			
Yes	0.56	0.10, 3.18	0.516
Having game machine at home			
Yes	0.94	0.62, 1.40	0.748
Home food environment scores			
Lowest	0.00		
Medium	0.91	0.59, 1.41	0.679
Highest	0.59	0.34, 1.03	0.063

At the parental characteristic level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Maternal pre-pregnant BMI status			
Underweight	0.00		
Normal	0.92	0.51, 1.66	0.791
Overweight	1.13	0.71, 1.78	0.613
Parental BMI status			
No parents overweight	0.00		
Father only overweight	1.25	0.78, 2.00	0.342
Mother only overweight	1.23	0.56, 2.70	0.610
Both parents overweight	1.70	1.02, 2.85	0.042
Father education level			
Primary school	0.00		
Secondary school	1.92	0.60, 6.13	0.272
High school	2.69	0.88, 8.17	0.082
College/ University	3.28	1.07, 10.04	0.038
Mother education level			
Primary school	0.00		
Secondary school	1.43	0.54, 3.75	0.469
High school	2.25	0.89, 5.67	0.085
College/ University	2.81	1.09, 7.25	0.032
Paternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.81	0.24, 2.69	0.731
Small business/ Skilled workers	2.08	0.67, 6.46	0.205
Traders	1.38	0.79, 2.44	0.261
Government officers	1.45	0.82, 2.55	0.197
Teacher/ Professionals	1.54	0.84, 2.82	0.162
Maternal occupations			
Laborer/ Street or home trader	0.00		
Home maker/ Others	0.72	0.13, 4.10	0.709
Small business/ Skilled workers	1.37	0.51, 3.69	0.534
Traders	1.70	0.64, 4.49	0.286
Government officers	2.22	0.83, 5.95	0.113
Teacher/ Professionals	1.87	0.62, 5.60	0.266

At the child's behaviour level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Duration of breast feeding months	0.97	0.94, 0.99	0.031
Duration of sleeping hours	0.72	0.55, 0.93	0.014
Energy (kca)l			
Lowest	0.00		
Medium	0.88	0.72, 1.07	0.214
Highest	0.93	0.78, 1.10	0.381
Macro-nutrients			
Protein (g)			
Lowest	0.00		
Medium	1.05	0.88, 1.24	0.599
Highest	1.15	0.91, 1.45	0.234
Energy from protein (%)			
Lowest	0.00		
Medium	1.03	0.87, 1.22	0.707
Highest	1.12	0.96, 1.30	0.135
Fat (g)			
Lowest	0.00		
Medium	0.98	0.77, 1.26	0.895
Highest	1.11	0.97, 1.35	0.117
Energy from fat (%)			
Lowest	1.00		
Medium	0.92	0.77, 1.10	0.357
Highest	1.08	0.89, 1.31	0.402
Carbohydrate (g)			
Lowest	1.00		
Medium	1.03	0.82, 1.30	0.770
Highest	1.06	0.91, 1.22	0.449
Energy from carbohydrate (%)			
Lowest	1.00		
Medium	1.03	0.92, 1.14	0.632
Highest	1.15	0.97, 1.37	0.094
Frequency of soft drink consumption			
Never			
< 1/week	0.35	0.16, 0.77	0.009
1-3 times/week	0.51	0.25, 1.01	0.053
>=4 times/week	0.75	0.47, 1.19	0.219
Frequency of ice cream consumption			
Never			
< 1/week	0.85	0.42, 1.71	0.642
1-3 times/week	0.95	0.56, 1.59	0.835
>=4 times/week	0.95	0.56, 1.59	0.835
Frequency of Western fast food			
Never	0.00		
< 1/week	1.15	0.71, 1.88	0.566
1-3 times/week	0.98	0.55, 1.76	0.949
>=4 times/week	1.72	0.94, 3.12	0.078

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Frequency of local fast food			
Never	0.00		
< 1/week	0.15	0.02, 1.03	0.054
1-3 times/week	1.00	0.34, 2.96	0.999
>=4 times/week	1.06	0.60, 1.85	0.841
Percentage of sedentary activity in a day			
Lowest	0.00		
Medium	0.92	0.79, 1.08	0.319
Highest	0.93	0.81, 1.07	0.303
Sedentary activity (hours)	0.99	0.95, 1.04	0.821
TV viewing (hours)	1.02	0.93, 1.11	0.683
Vigorous activities (hours)	0.97	0.89, 1.06	0.533

At the child's characteristic level

Factors	Unadjusted Relative Risk	95% CI	Wald's test p-value
Birth weight (100 grams)	1.05	1.01, 1.10	0.014
Pregnancy weight gain (kilograms)	1.02	0.98, 1.06	0.331
Gestational diabetes			
Yes	0.23	0.03, 1.59	0.136
Only child			
Yes	1.33	0.90, 1.97	0.153
Birth order			
1st	0.00		
2nd	0.83	0.53, 1.32	0.434
3rd	0.89	0.39, 1.99	0.783
4th	1.42	0.62, 3.23	0.407

[1] *No is reference*

Appendix 4

Multivariate analysis of factors associated with changes in each individual skinfold thickness

Hierarchical GEE models of predictors of the tracking of triceps skinfold thickness in girls over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of BMI in girls over the one year of follow-up from hierarchical GEE model

	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	0.79	0.64, 0.93	0.286	-0.36, 0.93	0.387
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.46	-0.27, 1.19	_	_	_
	Safety of environment					
	Yes[2]	-0.62	-1.50, 0.27	_	_	_
School environment	Amount of play equipments	-0.01	-0.05, 0.02	-0.04	-0.07, 0.0001	0.051
	School food environment scores					
	Lowest	0.00				
	Medium	0.65	-0.31, 1.60	_	_	_
	Highest	1.26	0.28, 2.23	_	_	_
Family environment	Wealth index					
	Poorest	0.00				
	Medium	0.41	-0.47, 1.30	_	_	_
	Richest	1.06	0.11, 2.01	_	_	_
	Cognitive scores					
	Lowest	0.00				
	Medium	0.05	-0.91, 1.00	_	_	_
	Highest	0.66	-0.24, 1.57	_	_	_
	Emotional scores					
	Lowest					
	Medium	1.29	0.16, 2.78	1.05	-0.19, 2.28	0.097
	Highest	1.47	-0.23, 2.10	1.48	0.24, 2.71	0.019
	Home good food scores					
	Lowest	0.00				
	Medium	-0.59	-1.47, 0.29	_	_	_
	Highest	-0.88	-1.81, 0.05	_	_	_
Parental characteristics	Paternal occupations					
	Labourer/ Street or home trader	0.00				
	Home maker/ Others	0.86	-0.85, 2.57	1.67	-1.14, 4.47	0.244
	Small business/ Skilled workers	0.05	-2.59, 2.70	1.16	-2.20, 4.51	0.520
	Traders	1.15	0.12, 2.18	1.38	-0.02, 2.79	0.054
	Government officers	1.47	0.43, 2.52	1.86	0.39, 3.33	0.013
	Teacher/ Professionals	1.57	0.48, 2.66	0.26	-1.31, 1.83	0.741

	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Child's behaviours	Duration of breast feeding (months)	-0.01	-0.04, 0.01	_	_	_
	Duration of sleeping (hours)	-0.38	-0.71, -0.05	_	_	_
	Sedentary activity (hours)	0.02	-0.02, 0.06	_	_	_
	TV viewing (hours)	0.10	0.02, 0.17	_	_	_
	Vigorous activities (hours)	0.001	-0.06, 0.06	_	_	_
Child's characteristics	Age (months)	0.13	0.11, 0.16	0.09	-0.02, 0.19	0.119
	Birth weight (100 grams)	0.05	-0.04, 0.13	_	_	_

Hierarchical GEE models of predictors of the tracking of TSF in boys over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of TSF in boys over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Time	0.79	0.64, 0.93	0.286	-0.36, 0.93	0.387
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.53	-0.36, 1.43	_	_	_
	Safety of environment					
	Yes	-1.01	-2.2, 0.14	-1.33	-2.58, -0.08	0.037
School environment	Number of play equipments	0.005	-0.04, 0.05	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	-1.01	-2.27, 0.24	_	_	_
	Highest	-0.36	-1.51, 0.79	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.31	-0.83, 1.46	0.52	-0.59, 1.64	0.362
	Richest	1.04	-0.09, 2.17	1.61	0.44, 2.78	0.007
	Cognitive scores					
	Lowest	0.00		0.00		
	Medium	0.98	-0.14, 2.10	0.63	-0.43, 1.68	0.245
	Highest	1.72	0.57, 2.88	1.56	0.44, 2.66	0.006
	Emotional scores					
	Lowest	0.00				
	Middle	-0.47	-2.31, 1.36	_	_	_
	Highest	0.49	-1.47, 2.46	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-0.75	-1.88, 0.39	-1.24	-2.42, -0.07	0.038
	Highest	-1.11	-2.24, 0.02	-1.58	-2.69, -0.46	0.005
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.36	-0.98, 1.71	_	_	_
	Overweight	0.53	-0.57, 1.62	_	_	_

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Parental BMI status					
	No parents overweight	0.00				
	Father only overweight	0.67	-0.50, 1.85	_	_	_
	Mother only overweight	-0.62	-2.55, 1.31	_	_	_
	Both parents overweight	1.42	-0.29, 3.13	_	_	_
Child's behaviours	Duration of breast feeding (months)	0.17	0.14, 0.20	-0.08	-0.14, -0.02	0.007
	Duration of sleeping (hours)	-0.45	-1.11, 0.21	_	_	_
	Sedentary behaviour (hours)	0.02	-0.13, 0.16	_	_	_
	Vigorous activities (hours)	-0.30	-0.47, -0.13	_	_	_
	TV viewing (hours)	0.11	-0.14, 0.36	_	_	_
Child's characteristics	Age (months)	0.04	0.03, 0.04	0.17	0.05, 0.28	0.006
	Birth weight (100 grams)	0.13	0.02, 0.23	0.13	0.02, 0.23	0.022

Hierarchical GEE models of predictors of the tracking of subscapular skinfold thickness in girls over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of SSSF in girls over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Community environment	Study time	0.58	0.49, 0.66	-0.01	-0.50, 0.47	0.95
	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.13	-0.66, 0.93	_	_	_
	Safety of environment					
	Yes	-0.69	-1.80, 0.43	_	_	_
School environment	Amount of play equipments	-0.003	-0.04, 0.03	_	_	_
	School food environment scores					
	Lowest	0.00				
	Medium	0.79	-0.35, 1.93	_	_	_
	Highest	1.42	0.39, 2.45	_	_	_
Family environment	Wealth index			2.13	-2.12, 6.38	0.327
	Poorest	0.00		-0.13	-3.65, 3.38	0.94
	Medium	0.59	-0.32, 1.51	1.96	0.37, 3.56	0.016
	Richest	1.33	0.29, 2.36	1.51	-0.19, 3.22	0.083
	Cognitive scores					
	Lowest	0.00				
	Medium	0.13	-0.91, 1.17	_	_	_
	Highest	0.37	-0.63, 1.38	_	_	_
	Emotional scores					
	Lowest	0.00				
	Medium	0.96	-0.44, 2.35	_	_	_
	Highest	1.20	-0.41, 2.80	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-0.68	-1.69, 0.33	-0.69	-2.32, 0.95	0.409
	Highest	-0.98	-1.97, 0.003	-1.90	-3.25, -0.55	0.006

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	-0.13	-1.13, 0.87	-0.021	-1.55, 1.51	0.979
	Overweight	1.14	0.20, 2.08	1.58	0.18, 2.98	0.027
	Parental BMI status					
	No parents overweight	0.00				
	Father only overweight	0.79	-0.23, 1.82	_	_	_
	Mother only overweight	0.28	-0.99, 1.55	_	_	_
	Both parents overweight	2.18	0.61, 3.75	_	_	_
Parental characteristics	Paternal occupations					
	Labourer/ Street or home trader	0.00				
	Home maker/ Others	0.96	-0.82, 2.74	2.13	-2.12, 6.38	0.327
	Small business/ Skilled workers	-0.48	-3.04, 2.08	-0.13	-3.65, 3.38	0.94
	Traders	1.53	0.45, 2.61	1.96	0.37, 3.56	0.016
	Government officers	1.85	0.64, 3.06	1.51	-0.19, 3.22	0.083
	Teacher/ Professionals	1.36	0.32, 2.41	0.47	-1.70, 2.63	0.674
Child's behaviours	Duration of breast feeding (months)	-0.02	-0.07, 0.03			
	Duration of sleeping (hours)	-0.21	-0.76, 0.34			
	Sedentary behaviour (hours)	0.05	-0.05, 0.15			
	TV viewing (hours)	0.22	0.05, 0.40			
	Vigorous activities (hours)	-0.09	-0.22, 0.03			
Child's characteristics	Age month	0.08	0.05, 0.10	0.08	-0.05, 0.20	0.218
	Birth weight (100 grams)	0.01	-0.09, 0.11			

Hierarchical GEE models of predictors of the tracking of subscapular skinfold thickness in boys over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of SSSF in boys over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	0.58	0.49, 0.66	-0.37	-1.15, 0.41	0.353
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.61	-0.34, 1.57	_	_	_
	Safety of environment					
	Yes	-1.01	-2.22, 0.21	-1.06	-1.97, -0.16	0.021
School environment	Amount of play equipments	0.01	-0.04, 0.07	-0.11	-0.21, -0.003	0.043
	School food environment scores					
	Lowest	0.00				
	Medium	-1.31	-2.63, 0.01	_	_	_
	Highest	-0.70	-1.88, 0.48	_	_	_

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	-0.23	-1.41, 0.95	-0.22	-1.37, 0.93	0.71
	Richest	0.83	-0.39, 2.05	1.40	0.08, 2.73	0.038
	Cognitive scores					
	Lowest	0.00		0.00		
	Medium	1.04	-0.09, 2.18	0.56	-0.54, 1.66	0.318
	Highest	1.67	0.46, 2.89	1.60	0.27, 2.93	0.018
	Emotional scores					
	Lowest	0.00				
	Medium	-0.24	-2.20, 1.71	_	_	_
	Highest	0.55	-1.51, 2.62	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Medium	-0.72	-1.92, 0.48	-0.95	-2.29, 0.39	0.166
	Highest	-1.26	-2.42, -0.09	-1.89	-3.11, -0.67	0.002
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.04	-1.24, 1.32	_	_	_
	Overweight	0.52	-0.63, 1.68	_	_	_
	Parental BMI status					
	No parents overweight	0.00				
	Father only overweight	1.04	-0.30, 2.37	_	_	_
	Mother only overweight	-0.77	-2.34, 0.79	_	_	_
	Both parents overweight	1.53	-0.21, 3.26	_	_	_
Child's behaviours	Duration of breast feeding (months)	-0.08	-0.14, -0.02	-0.09	-0.15, -0.03	0.005
	Duration of sleeping hours	-0.47	-1.22, 0.28	_	_	_
	Protein (grams)					
	Lowest	0.00				
	Medium	0.29	-0.09, 0.67	0.30	-0.05, 0.66	0.094
	Largest	0.41	0.06, 0.77	0.46	0.12, 0.81	0.008
	Sedentary behaviour (hours)	0.02	-0.13, 0.16	_	_	_
	TV viewing (hours)	-0.3	-0.47, -0.13	_	_	_
	Vigorous activities (hours)	0.11	-0.14, 0.36	_	_	_
Child's characteristics	Age (months)	0.12	0.09, 0.14	0.18	0.05, 0.31	0.008
	Birth weight (100 grams)	0.09	-0.02, 0.20	_	_	_

Hierarchical GEE models of predictors of the tracking of suprailiac skinfold thickness in girls over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of SISF in girls over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	1.02	0.84, 1.84	0.13	-0.64, 0.90	0.744
Community environment	Resident location					
	Less wealthy districts	0.00				
	Wealthy districts	0.75	-0.14, 1.64	_	_	_
	Safety of environment					
	Yes	-0.77	-1.92, 0.39	_	_	_
School environment	Amount of play equipments	0.01	-0.04, 0.05	_	_	_
	School food environment scores					
	Lowest	0.00		0.00		
	Medium	1.48	0.35, 2.60	1.60	0.55, 2.66	0.003
	Highest	1.61	0.36, 2.86	2.09	0.83, 3.35	0.001
Family environment	Wealth index					
	Poorest	0.00				
	Medium	0.68	-0.39, 1.75	_	_	_
	Richest	1.43	0.28, 2.59	_	_	_
	Cognitive scores					
	Lowest	0.00				
	Middle	-0.03	-1.18, 1.12	_	_	_
	Highest	0.66	-0.47, 1.80	_	_	_
	Emotional scores					
	Lowest	0.00		0.00		
	Middle	1.62	0.01, 3.24	1.86	0.55, 2.65	0.003
	Highest	1.84	0.25, 3.43	2.27	0.59, 3.95	0.008
	Home food environment scores					
	Lowest	0.00		0.00		
	Middle	-0.75	-1.87, 0.37	-0.84	-2.63, 0.93	0.351
	Highest	-1.13	-2.24, -0.03	-1.81	-3.34, -0.27	0.021
Parental characteristics	Maternal pre-pregnant BMI status					
	Underweight	0.00				
	Normal	0.13	-1.16, 1.41	_	_	_
	Overweight	0.92	-0.14, 1.99	_	_	_
	Paternal occupations					
	Labourer/ Street or home trader	0.00		0.00		
	Home maker/ Others	0.33	-1.34, 2.01	2.26	-0.19, 4.72	0.071
	Small business/ Skilled workers	-0.42	-3.53, 2.69	0.38	-4.08, 4.84	0.866
	Traders	1.26	0.05, 2.48	1.84	0.19, 3.49	0.029
	Government officers	2.28	0.90, 3.65	2.65	0.41, 4.89	0.020
	Teacher/ Professionals	1.91	0.62, 3.20	0.711	-1.35, 2.78	0.499
Child's behaviours	Duration of breast feeding months	-0.06	-0.11, -0.01	-0.06	-0.11, -0.02	0.006
	Duration of sleeping (hours)	-0.52	-1.13, 0.09	_	_	_
	Sedentary activity (hours)	0.08	-0.07, 0.24	_	_	_
	TV viewing (hours)	0.39	0.13, 0.65	_	_	_
	Vigorous activities (hours)	-0.30	-0.47, -0.13	_	_	_

Child's characteristics	Age month	0.17	0.14, 0.20	0.15	0.02, 0.28	0.02
	Birth weight (100 grams)	0.005	-0.11, 0.12	_	_	_

Hierarchical GEE models of predictors of the tracking of suprailiac skinfold thickness in boys over the one year of follow-up

The adjusted coefficients and the 95% confidence interval of predictors of the tracking of SISF in boys over the one year of follow-up from hierarchical GEE model

Levels	Predictors	Unadjusted coefficients	95% CI	Adjusted coefficients	95% CI	p-value
	Study time	1.15	0.96, 1.34	-0.18	-1.07, 0.70	0.683
Community environment	Resident location					
	Less wealthy districts	0.00		0.00		
	Wealthy districts	0.59	-0.49, 1.66	0.72	0.02, 1.41	0.044
	Safety of environment					
	Yes	-1.42	-2.81, -0.04	-1.02	-1.92, -0.12	0.027
School environment	Amount of play equipments	0.02	-0.04, 0.08	0.72	0.02, 1.41	0.044
	School food environment scores					
	Lowest	0.00				
	Medium	-0.68	-2.03, 0.66	_	_	_
	Highest	-0.69	-2.03, 0.66	_	_	_
Family environment	Wealth index					
	Poorest	0.00		0.00		
	Medium	0.24	-1.11, 1.60	0.31	-1.02, 1.63	0.649
	Richest	1.33	0.42, 2.24	1.45	0.01, 2.89	0.048
	Cognitive scores					
	Lowest	0.00		0.00		
	Middle	1.82	0.49, 3.16	1.46	0.17, 2.75	0.027
	Highest	2.38	1.03, 3.73	2.15	0.81, 3.49	0.002
	Emotional scores					
	Lowest	0.00				
	Middle	0.33	-1.84, 2.49	_	_	_
	Highest	1.18	-1.07, 3.44	_	_	_
	Home food environment scores					
	Lowest	0.00		0.00		
	Middle	-0.22	-1.58, 1.13	-0.64	-2.05, 0.77	0.373
	Highest	-0.92	-2.30, 0.46	-1.41	-2.75, -0.07	0.039
Parental characteristics	Maternal pre-pregnant BMI status			1.45	0.01, 2.89	0.048
	Underweight	0.00				
	Normal	-0.21	-1.74, 1.31	0.00		
	Overweight	0.86	-1.74, 1.31	1.46	0.17, 2.75	0.027
	Parental BMI status			2.15	0.81, 3.49	0.002
	No parents overweight	0.00				
	Mother only overweight	0.72	-0.74, 2.17	_	_	_
	Father only overweight	-0.74	-3.06, 1.58	_	_	_
	Both parents overweight	1.36	-0.45, 3.17	_	_	_
Child's behaviours	Duration of breast feeding (months)	-0.08	-0.15, -0.01	-0.07	-0.14, -0.01	0.026
	Duration of sleeping (hours)	-0.57	-1.40, 0.26	_	_	_
	Sedentary activity (hours)	0.03	-0.15, 0.20	_	_	_
	TV viewing (hours)	0.20	-0.09, 0.50	_	_	_
	Vigorous activities (hours)	-0.39	-0.61, -0.16	_	_	_

Child's characteristics	Age (months)	0.20	0.17, 0.23	0.23	0.08, 0.38	0.003
	Birth weight (100 grams)	0.12	-0.01, 0.25	_	_	_