



NEAT Girls

Nutrition and Enjoyable Activity for Teen Girls

**Nutrition and Enjoyable Activity for Teen Girls
(NEAT Girls) Group Randomised Controlled Trial:
Evaluation of a School-based Obesity Prevention Program for
Adolescent Girls from Low-income Communities**

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**Nutrition and Enjoyable Activity for Teen Girls
(NEAT Girls) Group Randomised Controlled Trial: Evaluation of a
School-based Obesity Prevention Program for Adolescent Girls from
Low-income Communities**

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Statement of Originality

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Acknowledgement of Authorship

I hereby certify that this thesis is in the form of a series of published papers of which I am a joint author. I have included as part of my thesis a written statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

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List of Abbreviations

ABS	Australian Bureau of Statistics
AGFI	Adjusted goodness-of-fit index
ANOVA	Analysis of variance
APD	Accredited practising dieticians
ASAQ	Adolescent sedentary activity questionnaire
BL89	Bollen's fit index
BMI	Body mass index
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence intervals
CPM	Counts per minute
CONSORT	Consolidated standards of reporting trials
<i>df</i>	Degrees of freedom
DOIT	Dutch obesity intervention in teenagers
DXA	Dual-energy x-ray absorptiometry
FFQ	Food frequency questionnaire
FM	Fat mass
FFM	Fat free mass
GEMS	Girls enrichment multi-site studies
GFI	Goodness-of-fit index
HPM	Health promotion model
HBM	Health belief model
ICAPS	Intervention centred on adolescents' physical activity & sedentary behaviour
ICC	Intra-class correlation coefficient
KCal	Kilo-calories
Kg	Kilogram
KOPs	Kiel obesity prevention study
LEAP	Lifestyle education for activity program
M	Mean
m	Metre
Mc	McDonald's centrality index

METs	Metabolic equivalent
ml	millimetre
MLE	Maximum likelihood analysis
MPA	Moderate physical activity
M-SPAN	Middle school physical activity and nutrition
MVPA	Moderate-to-vigorous physical activity
N	Number
NEAT	Nutrition and enjoyable activity for teen (girls)
NNFI	Non-normed fit index
NSW	New South Wales
<i>p</i>	Probability (statistical significance level)
PACE+	Patient-centred assessment and counselling for exercise + nutrition
PE	Physical education
RA	Research assistant
RCT	Randomised controlled trial
RMSEA	Root mean square error of approximation
RNI	Relative non-centrality index
SCT	Social Cognitive theory
SD	Standard deviation
SDT	Self-determination theory
SEIFA	Socio-economic indices for areas
SEM	Structural equation modelling
SEP	Socio-economic position
SPANS	Schools physical activity and nutrition survey
SRMR	Standardised root mean square residual
SSB	Sugar-sweetened beverage
SSR	Small-screen recreation
TAAG	Trial of activity for adolescent girls
T1	Time one
T2	Time two
TLI	Tucker-Lewis index
TPB	Theory of planned behaviour
TRA	Theory of Reasoned Action
TTM	Transtheoretical model

TV	Television
U	Units
UK	United Kingdom
US	United States
VPA	Vigorous physical activity

Abstract

Current rates of obesity among youth are high and prevalence continues to increase most rapidly among those of low socio-economic position (SEP). Overweight and obesity are a major cause of preventable morbidity and mortality, and given the high likelihood of paediatric obesity persisting into adulthood, effective behavioural interventions that target high-risk groups are urgently needed. Adolescent girls of low-SEP require priority attention because they are particularly susceptible to demonstrating poor health behaviours implicated in the development of obesity.

Primary Aim

The primary aim of this thesis was to evaluate a 12-month, school-based obesity prevention intervention targeting adolescent girls living in low-income communities. The Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) intervention was evaluated using a group randomised controlled trial (RCT) that involved 357 adolescent girls ($M = 13.2$ years, $SD = 0.5$) from six intervention and six control schools located in the Newcastle, Central Coast and Hunter areas of New South Wales, Australia. The multi-component intervention was guided by Social Cognitive Theory (SCT) and focused on promoting physical activity, healthy eating and reducing sedentary behaviours. The program components included enhanced school sport and lunchtime physical activity sessions, nutrition workshops, interactive educational seminars, student handbooks, pedometers for self-monitoring, text messages to encourage the targeted health behaviours, and newsletters for parents.

Assessments were conducted at baseline, 12- (post-test) and 24- months (follow-up). The primary outcome measure was body mass index (BMI), and secondary outcomes included BMI z -score, percentage body fat (bioelectrical impedance analysis), physical activity (accelerometers), dietary intake and sedentary behaviour (self-report), muscular fitness (sit-up and prone hold tests), physical self-perceptions, self-esteem, and hypothesised social-cognitive mediators of physical activity and dietary behaviour change (questionnaires).

After 12- and 24- months, relative to the control group, the intervention group demonstrated improvements in all body composition outcomes, although there was no statistically significant effect on the primary outcome (BMI). Only changes in percentage body fat were statistically significant after 24-month follow-up (adjusted mean difference [95% confidence intervals] = -2.0% [-3.0 to -0.9], $p = .006$). After 12-months, girls in the intervention group reported 31 mins/day less [-62 to -1], $p = .024$) screen time than their control group peers. There were no significant group-by-time effects for any of the remaining outcomes.

These findings provide some evidence for the benefit of a school-based intervention to prevent unhealthy weight gain in adolescent girls living in low-income communities. Considering the range of adverse health consequences associated with excessive time spent in sedentary behaviours, the large reductions in screen time observed in the current study may have important implications for adolescent girls.

Secondary Aims

Few studies have examined the psychosocial mediators of physical activity and dietary behaviour change in adolescents and the poor quality of existing measures has compounded the lack of available evidence. Therefore, a secondary aim of this thesis was to develop and evaluate social-cognitive measures related to adolescent physical activity and dietary behaviours. Two questionnaires, each relating to physical activity or dietary behaviour, based on the following constructs from SCT were developed: self-efficacy, intention (proximal goals), situation (perceived barriers/facilitators of the physical environment), social support, behavioural strategies, and outcome expectations and expectancies. In the first stage of development, the scales were reviewed by an expert panel and then further refined during a focus group conducted with adolescents ($n = 12$, 14.1 ± 0.6 years). In the second stage, the scales were pilot tested in a sample of secondary school students ($n = 173$, 13.7 ± 1.2 years) that was independent of the NEAT Girls study sample. Reliability of the measures was assessed using a two-week test-retest (intra-class correlation coefficients [ICC] and internal consistency [Cronbach's alpha]). Construct validity was also assessed by confirmatory factor

analyses (CFA) to establish model fit of each scale by using multiple fit indices. All scales demonstrated sound reliability (ICC = 0.81 to 0.91; α = 0.63 to 0.79) and fit indices indicated each model to be an adequate-to-exact fit to the data. As such, these scales were used to measure hypothesised social-cognitive determinants of physical activity and dietary behaviour in the NEAT Girls study, and may provide suitable use for future research investigating social-cognitive correlates and mediators of physical activity and dietary behaviour, and the evaluation of theoretical models based on the SCT.

An additional secondary aim involved performing a longitudinal test of the hypothesised paths of influence in Bandura's SCT model to explain change in physical activity behaviour (moderate-to-vigorous physical activity [MVPA] minutes using accelerometry) following the NEAT Girls 12-month intervention. In the model, it was hypothesised that self-efficacy, outcome expectations and intention (proximal goals) related to physical activity would predict change in physical activity, and that self-efficacy, outcome expectations and parental support for being physically active would predict physical activity intention. Structural equation modelling was used to test the model. Although model-fit indices indicated the model was an adequate fit to the data, the amount of variance explained for physical activity (28%) and intention (34%) was small. Further, the proposed pathways linking the social-cognitive influences to behaviour change were not well supported. Only self-efficacy predicted change in physical activity.

Support for the SCT model to predict change in physical activity behaviour was not strong. Future model testing should consider augmentation or integration of theory, including ecological components, to advance our understanding of health behaviours in adolescent girls of low-SEP.

Chapter 1: Introduction

1.1 Background and Context

The physical, social, emotional and financial burden of obesity and associated health behaviours are well documented (Denney-Wilson, Hardy, Dobbins, Okely & Baur, 2008; Gill, Bauer & Bauman, 2009; Reilly & Kelly, 2011). Although the more immediate consequences of paediatric obesity are largely psychosocial (Wake et al., 2010), the risks of long-term morbidity and mortality are increased with insufficient physical activity, poor diet and excessive sedentary behaviour (Hu et al., 2007; Janssen et al., 2005; Katzmarzyk, Church, Craig & Bouchard, 2009; Strong et al., 2005).

Currently, one in four Australian adolescents are overweight or obese (Hardy, King, Espinal, Cosgrove & Bauman, 2011; Olds, Tomkinson, Ferrar & Maher, 2010) and behavioural trends implicated in unhealthy weight gain during adolescence is of concern. In particular, there is good evidence to suggest that adolescent girls and individuals from low socio-economic groups exhibit some of the poorest physical activity, dietary and sedentary behaviours (Hardy, Bass & Booth, 2007; Hardy et al., 2011; Okely, Booth, Hardy, Dobbins & Denney-Wilson, 2008). Moreover, adolescence is a period characterised by growing autonomy, with health behaviours established during this period likely to influence long-term behaviours and health outcomes (Telama et al., 2005; Viner & Cole, 2005).

Indeed, the benefits of regular physical activity, healthy eating and reducing sedentary behaviours extend well beyond the prevention of unhealthy weight gain to include favourable physiological and psychosocial health and cognitive outcomes. For example, well documented benefits include maintenance of healthier bones, joints and muscles, a reduction in the symptoms of depression and anxiety, an improved metabolic profile through reducing the risk for chronic disease, and enhanced concentration and academic performance (Janssen & LeBlanc, 2010; Strong et al., 2005; Tremblay, LeBlanc, Kho et al., 2011). Therefore, there is a strong case for prevention programs that target adolescent groups identified as at high risk for obesity. Finding effective means for improving the health behaviours of these sub-groups of the adolescent population is a national priority.

1.2 Research Aims and Questions

The primary aim of this thesis was to evaluate a school-based obesity prevention intervention for adolescent girls of low-SEP. Secondary aims were to 1) evaluate the psychometric properties of social-cognitive measures related to adolescent physical activity and dietary behaviour; and 2) to test the utility of a theoretical model of health behaviour in adolescent girls of low-SEP to explain change in physical activity.

1.3 Research Questions

1.3.1 Primary Research Questions

1. What are the effects of a school-based obesity prevention intervention for adolescent girls living in low-income communities on:
 - body composition
 - physical activity, dietary and sedentary behaviours
 - muscular fitness
 - physical self-perceptions and self-esteem
 - hypothesised social-cognitive influences of physical activity and dietary behaviour?
2. Were changes in physical activity and dietary behaviour mediated by social-cognitive constructs?

1.3.2 Secondary Research Questions

1. What is the reliability and construct validity of social-cognitive measures related to dietary behaviour in adolescents?
2. What is the reliability and construct validity of social-cognitive measures related to physical activity behaviour in adolescents?
3. Can constructs from SCT explain change in physical activity following a 12-month physical activity intervention to prevent obesity in adolescent girls of low-SEP?

1.4 Thesis Structure

1.4.1 Overview

This thesis begins with an overview of the literature (Chapter 2). The background, methods, results and discussion of findings and implications of the research conducted for this thesis are then presented as a series of seven research papers (Chapters 3 to 9). The seven papers present work from a body of research made up of three key areas:

1. the development and psychometric evaluation of two social-cognitive measures related to adolescent dietary and physical activity behaviour (Chapters 3 and 4),
2. a test of SCT to explain change in physical activity behaviour in adolescent girls of low-SEP (Chapter 6),
3. the evaluation of school-based obesity prevention program for adolescent girls of low-SEP (Chapters 5, 7–9).

Following this configuration, findings from the secondary research aims are presented first in this thesis, followed by findings from the primary research aim. Figure 1.1 outlines how each key area of research relates to the research aims, questions and papers presented. A brief overview of each key area of research is provided below. An overall discussion of the findings from each key area, and the implications for future research and practice are provided in the final chapter of the thesis (Chapter 10).

1.4.2 The Development and Psychometric Evaluation of Two Social-cognitive Measures Related to Adolescent Dietary and Physical Activity Behaviour

Two separate measures, each comprising a set of social-cognitive scales related to adolescent physical activity or dietary behaviour, were developed for use in the NEAT Girls intervention study. In the first stage of development, the scales were reviewed by experts in the field then further refined following a focus group with 12 adolescents (14.1 ± 0.6 years). Next, the scales were administered in a cohort of secondary school students ($n = 173$) not involved in the NEAT Girls RCT, using a two-week test-retest design. Psychometric testing of each scale was performed to determine reliability and construct validity properties. The detailed methods and results for this study are presented in two papers (Chapters 3 and 4). The scales demonstrated sound statistical

properties and were subsequently used to test the utility of SCT to predict change in physical activity behaviour using longitudinal data from the group RCT described in section 1.4.3 below.

1.4.3 A Test of SCT to Explain Change in Physical Activity Behaviour in Adolescent Girls of Low-SEP

Data from the RCT described in section 1.4.4 were used to test the utility of SCT to explain change in physical activity behaviour in adolescent girls of low-SEP. In Bandura's (2004) reconceptualised SCT, self-efficacy is hypothesised to predict health behaviour both directly and indirectly through other determinants, which include outcome expectations, goals and facilitators/impediments to behaviour.

In a longitudinal study, the utility of Bandura's (2004) SCT model was examined to explain change in physical activity (daily MVPA minutes) over a 12-month period following the NEAT Girls intervention. Participants completed validated social-cognitive scales (described above in section 1.4.2) assessing MVPA related self-efficacy, intention (proximal goals), parental support and outcome expectations. Physical activity data from accelerometers were included as the dependent variable.

The hypothesised paths of influence shown in Bandura's 2004 model between the specified SCT constructs and change in physical activity were also examined. Chapter 6 presents in detail the methods and results for this study.

1.4.4 Evaluation of a School-based Obesity Prevention Program for Adolescent Girls Living in Low-income Communities

The feature study presented in this thesis was a group RCT used to evaluate the impact of an obesity prevention program for adolescent girls attending schools in low-income communities. The 12 month intervention included assessments at baseline, 12- and 24-month follow-up. Twelve eligible schools were recruited (based on a Socio-Economic Indices for Areas [SEIFA] index ≤ 5 . This index is derived from information [e.g., education, employment and financial well-being] used to characterise individuals and households in a specified area). Study participants were identified as physically inactive

at the time of recruitment, and were in Grade 8 during baseline assessments ($M = 13.2$ years, $SD = 0.5$). Guided by SCT, the multi-component intervention employed a range of strategies to prevent unhealthy weight gain through improved physical activity, dietary and sedentary behaviours. The intervention was evaluated in terms of impact on body composition, behaviour (diet, physical activity and time spent sedentary), fitness, self-esteem and various physical self-perceptions. SCT constructs were hypothesised to influence positive changes in physical activity and dietary behaviour.

1.5 Ethics

Ethics approval for the study described in section 1.4.2 was obtained from the University of Newcastle Human Research Ethics Committee (H-2009-0320). Ethics approval for the studies described in section 1.4.3 and 1.4.4 were obtained from the University of Newcastle (H-2009-0398) and New South Wales Department of Education and Training (2009177) Human Research Ethics Committees.

	Area of study	Research questions	Thesis chapter: Research paper
Secondary research aims	Development and psychometric evaluation of measures	<ol style="list-style-type: none"> 1. <i>What is the reliability and construct validity of social-cognitive measures related to adolescent dietary behaviour?</i> 2. <i>What is the reliability and construct validity of social-cognitive measures related to adolescent physical activity behaviour?</i> 	<p>Chapter 3: Social-cognitive Scales Related to Adolescent Dietary Behaviour: Development & Evaluation.</p> <p>Chapter 4: Social-cognitive Scales Related to Adolescent Physical Activity Behaviour: Development & Evaluation.</p>
	Testing SCT to explain change in physical activity	<ol style="list-style-type: none"> 3. <i>Can constructs from SCT accurately explain change in physical activity following a 12-month behavioural intervention to prevent obesity in adolescent girls of low-SEP?</i> 	<p>Chapter 6: A Longitudinal Test of the SCT to Explain Change in Physical Activity Behaviour in Adolescent Girls of Low-SEP.</p>
Primary research aim	Evaluation of a group randomised controlled trial to prevent obesity	<ol style="list-style-type: none"> 1. <i>What are the effects of a school-based obesity prevention intervention for adolescent girls of low-SEP?</i> 2. <i>Are changes in dietary and physical activity behaviour mediated by social-cognitive constructs?</i> 	<p>Chapter 5: A Randomised Controlled Trial to Prevent Obesity in Adolescent Girls of Low-SEP: Study Protocol and Baseline Findings.</p> <p>Chapters 7 & 8: One-year Outcomes of the NEAT Girls Obesity Prevention Intervention: Part One and Part Two.</p> <p>Chapter 9: Two-year Outcomes of the NEAT Girls Obesity Prevention Intervention.</p>

Figure 1.1: Relationship between key areas of research, research papers and research questions

Chapter 2: Literature Review

2.1 Overview

Chapter 2 is divided into three sections (see Figure 2.1). The first section provides a rationale for obesity prevention interventions targeting adolescent girls of low-SEP. Current trends of adolescent health behaviours implicated in the development of overweight and obesity are described, with particular attention given to adolescent girls of low-SEP. The evidence-based health implications of these behaviours are also discussed. Current guidelines and recommendations for adolescent physical activity, dietary and sedentary behaviours are outlined.

The second section provides an overview of the factors that influence physical activity, dietary and sedentary behaviours in adolescents. Specifically, evidence-based correlates of behaviour and mediators of behaviour change are discussed. Relevant theories used to explain health behaviours are also described in the context of adolescent physical activity, dietary and sedentary behaviour.

Finally, the third section provides an overview of interventions to prevent obesity in adolescents. Study designs, settings, samples and evaluation measures are compared to identify limitations and gaps in the evidence.

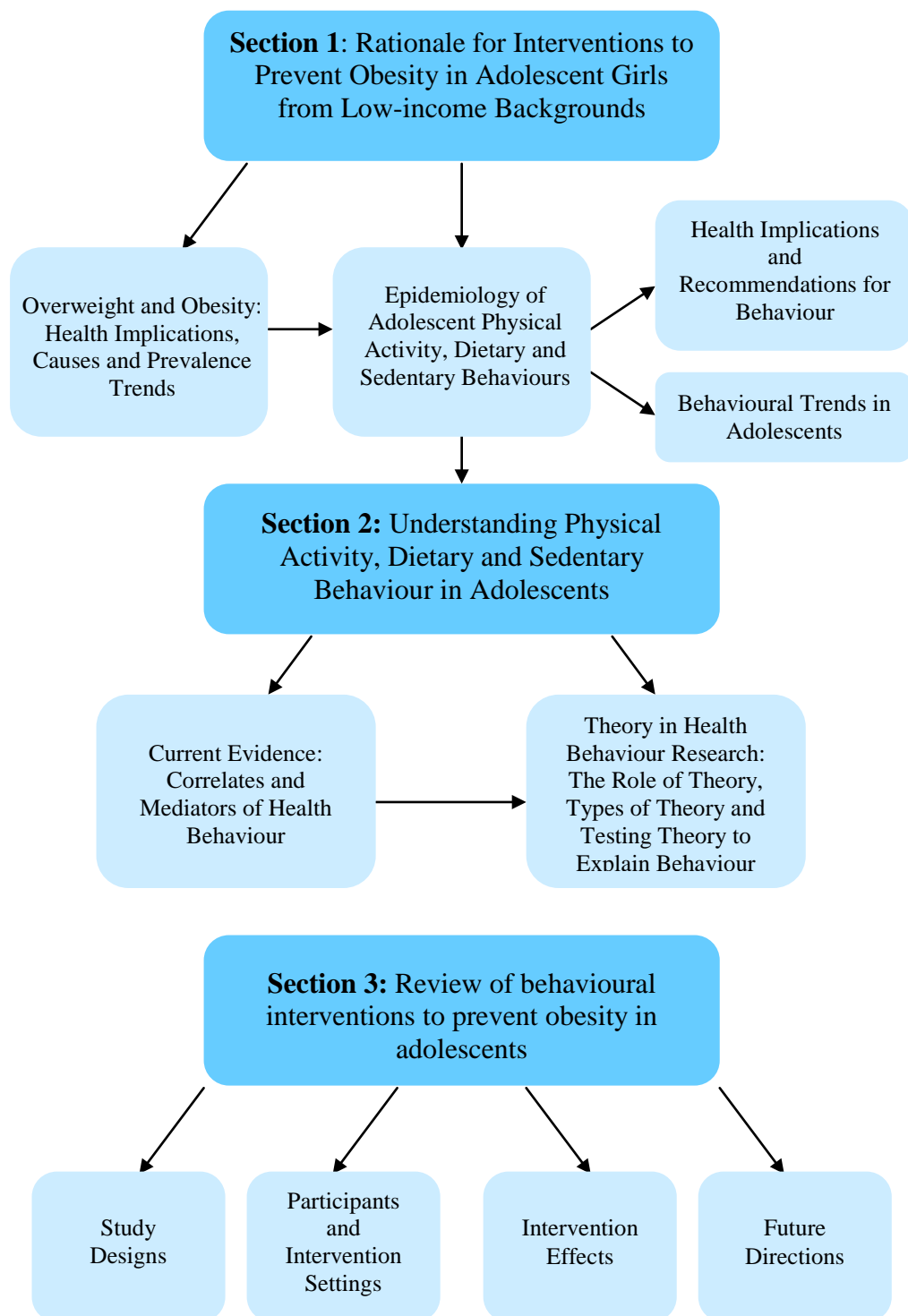


Figure 2.1: Schematic diagram of literature review

2.2 Overweight and Obesity: The Health Implications, Causes and Prevalence

2.2.1 The Health Implications

The immediate and long-term consequences of paediatric obesity are deleterious (Denney-Wilson, Hardy, Dobbins, Okely & Baur, 2008; Gill, Bauer & Bauman, 2009; Reilly & Kelly, 2011). There is strong evidence to demonstrate that an increase in body fat is an important risk factor for cardiovascular disease and Type 2 diabetes in children and adolescents (Goran, Ball & Cruz, 2003), and even modest changes in body composition can impact markers of these chronic diseases (Dai et al., 2009; Foster et al., 2010). For example, longitudinal research tracking changes in adiposity in children and adolescents found a 1% increase in adiposity was associated with adverse changes in plasma lipids, including total cholesterol and triglycerides, which are precursors of heart disease (Dai et al., 2009). Other more immediately developed conditions can include breathing difficulties, insulin resistance, sleep apnoea and an increased risk of fractures (Lobstein, Baur & Uauy, 2004). In addition, the incidence of other weight-related orthopaedic conditions previously seen in the adult population are now also being observed among older children and adolescents (Murray & Wilson, 2008). In their recent review, Nguyen and colleagues (2011) reported an increase in paediatric obesity in Australia during the last 20 years was accompanied by a significant increase in the incidence of hip disorders diagnosed in adolescents (e.g., displacement of the growth plate in the upper femur).

Perhaps the most immediate consequences of paediatric obesity are psychosocial, as overweight and obese youth report poorer social and mental health compared to those who are a healthy weight (Wake et al., 2010). Chaiton and colleagues (2009) also found an association between depression, pressure to be thin and body dissatisfaction to be an indicator linked with obesity prevalence in nearly two-thirds of adolescents studied, particularly among girls.

Of additional concern is the high likelihood of paediatric-onset obesity tracking into adulthood (Singh, Mulder, Twisk & Chinapaw, 2008), further complicating the physical and psychosocial ramifications on health and wellbeing (Johnson, Gerstein, Evans &

Woodward-Lopez, 2006). In fact, it has been shown that regardless of adult weight status, adults are at a higher risk for morbidity and mortality if obese as an adolescent (Must, Jacques, Dallal, Bajema & Dietz, 1992).

The burden of paediatric obesity on the health care system is less well known, although the overall economic impact in Australia appears extensive. In 2008, it was estimated that the direct financial cost of obesity in Australia was AU\$8.3 billion, while indirect costs were estimated to amount to AU\$41.9 billion (Access Economics, 2008). Whilst these estimates do not include the economic burden of ‘overweight’ in Australia, clearly the tangible cost of overweight and obesity combined is much higher.

2.2.2 Causes

There is good evidence to show that excessive unhealthy weight gain is caused by a chronic energy imbalance involving both dietary intake and insufficient physical activity (Gortmaker et al., 2011). For example, increases in energy intake have been implicated in changes in the global food system that have led to mass production and consumption of highly processed and energy-dense foods (i.e., added sugar, fat, salt and flavour enhancers; Cutler, Glaeser & Shapiro, 2003). International trends also show a decrease in physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation and increasing urbanisation (World Health Organization, 2006). Experts have also implicated excessive sedentary activity in the causal path to unhealthy weight gain (Kamath et al., 2008; Tremblay et al., 2010; Tremblay et al., 2011). In fact, there is substantial evidence linking the number of hours of television (TV) viewing to overweight and obesity in children and adolescents (Tremblay & Willms, 2003).

Indeed, it is clear that other factors can facilitate these behaviours including government policy, economics, the built environment and cultural norms that can help to explain observed disparities in obesity prevalence across and within populations (Swinburn et al., 2011). For example, prevalence trends for obesity show high incidence in low- and middle-income countries among groups of high-SEP and in urban settings, but in developed countries, the burden of obesity is more evident among low-SEP groups and rural areas (Monteiro, Moura, Conde & Popkin, 2004).

Subsequently, we have seen rising rates of obesity persist over the past 30 years in all countries of the world (Finucane et al., 2011). In fact, it has been suggested that global prevalence of obesity has reached epidemic proportions, and with no signs of the epidemic easing, the need for many sustained interventions at multiple levels has been recognised (Gortmaker et al., 2011).

2.2.3 Global Prevalence and Adolescent Trends

The global rise of obesity prevalence appeared to begin during the 1970s and 1980s in most high-income countries, but then most middle-income and many low-income countries were to join the global surge (Swinburn et al., 2011). By 2008, an estimated 1.96 billion adults globally were overweight (BMI > 25 kg/m²) or obese (BMI > 30 kg/m²). Further, an estimated 170 million children (aged < 18 years) globally were classified as overweight or obese (Swinburn et al., 2011). More recently, high and increasing rates of childhood and adolescent obesity have been reported globally (Gortmaker et al., 2011), and Australian youth are not impervious to this modern day epidemic.

The incidence of childhood and adolescent obesity in Australia has at least doubled in the last 25 years (Hardy et al., 2011; Olds et al., 2010). For example, in their recent review, Olds and colleagues (2010) reported that the estimated prevalence of childhood overweight and obesity increased from approximately one in 10 in 1985 to almost one in four in 2008. Further, it has been predicted that the prevalence of overweight among Australian children will grow to 60% within the next 20 years, matching current rates among the Australian adult population (Norton, Dollman, Martin & Harten, 2006).

Other data suggest that, in the last decade, the rise in overweight and obesity for youth begun to plateau in some countries including Australia, England, France and the United States (O'Dea, 2008; Olds et al., 2010; Péneau et al., 2009; Stamatakis, Wardle & Cole, 2010). However, this trend has not been observed among youth of low-SEP. For example, Stamatakis and colleagues (2010) examined changes in overweight and obesity among school-age youth in England between 1997 and 2007 and found that overall prevalence trends had stabilised, yet rates continued to increase among those of

low-SEP. Similarly, Dollman et al. (2005) reported a significant increase in adiposity between 1997 and 2002 among Australian girls of low-SEP, but not among girls of high-SEP. In fact, recent Australian data are consistent to indicate that overweight and obesity is more prevalent among adolescents of low-SEP, compared to those of high-SEP (Hardy et al., 2011; O'Dea, 2008).

In summary, considering the negative implications of unhealthy weight gain, the high risk of paediatric-onset obesity persisting into adulthood, and the difficulty in treating obesity in adults (Oude Luttikhuis et al., 2009), it is clear that children and adolescents are priority populations for prevention programs. In particular, the evidence suggests adolescents of low-SEP require priority attention and that targeted interventions that meet the needs of this high-risk group are necessary.

2.3 Epidemiology of Adolescent Physical Activity, Dietary and Sedentary Behaviours

In addition to unhealthy weight gain, it is well established that a lack of physical activity, poor nutrition and sedentary behaviour increase the risk for a variety of acute and chronic health problems (Hu et al., 2007; Janssen & LeBlanc, 2010; Katzmarzyk et al., 2009; Strong et al., 2005). Since these three health behaviours are independent risk factors for morbidity and mortality, the health implications of each are described separately in this section. Current recommendations and trends for physical activity, dietary and sedentary behaviour in adolescents are also described.

2.3.1 Health Implications and Behavioural Recommendations

2.3.1.1 Physical Activity

There is good evidence that participation in regular physical activity reduces the risk for a variety of chronic diseases. For example, regular physical activity has been associated with immediate improvements in blood pressure, cholesterol and blood insulin levels, which are important predictors of conditions such as osteoporosis, coronary heart disease, non-insulin dependent diabetes and colon cancer (US Department of Health & Human Services, 1996). Further, the health benefits include maintenance of healthier

bones, joints, muscles and weight control and a reduction in the symptoms of depression and anxiety (US Department of Health & Human Services, 1996).

Even during childhood and adolescence, important benefits of physical activity have been documented. These benefits include favourable skeletal development and improved metabolic profile and psychological wellbeing (Janssen & LeBlanc, 2010; Strong et al., 2005). There are data to demonstrate lower physical activity levels are associated with a higher prevalence of obesity in children (Katzmarzyk et al., 2008; Strong et al., 2005). In addition, children and adolescents who participate in regular physical activity have reported improved self-esteem and self-concept, and a reduction in symptoms of anxiety and depression (Ekeland, Heian, Hagen, Abbott & Nordheim, 2004; Strong et al., 2005). Finally, long-term tracking of physical activity behaviours have shown that high levels of participation established during childhood predicts a high level of adult physical activity (Telama et al., 2005) and hence through it, positive public health repercussions.

Indeed, to gain the health benefits of physical activity, it has been emphasised that a 'moderate' level of activity is at least required, which involves expending approximately 150 calories (approximately 627 kilojoules) per day, and that the amount of health benefit is related to the frequency and duration of participation (US Department of Health & Human Services, 1996). Current physical activity guidelines for Australian adolescents (12–18 years) are consistent with internationally recognised recommendations of at least 60 minutes per day of physical activity (Department of Health and Ageing, 2010; Tremblay, Warburton et al., 2011; US Department of Health & Human Services, 2008). Most of the 60 minutes should be moderate- or vigorous-intensity aerobic activity, with at least three days per week including 20 minutes of vigorous intensity activity. Examples of moderate-intensity activity are brisk walking, swimming, doubles tennis and medium-paced cycling. More vigorous physical activity includes jogging and active sports like football and basketball. Additionally, current Canadian and US guidelines recommend the inclusion of physical activities, which promote bone- and muscle- strengthening on at least three days per week as part of the 60 minutes (Tremblay, Warburton et al., 2011; US Department of Health & Human Services, 2008).

2.3.1.2 Dietary Behaviour

Healthful eating that encompasses nutrient-rich, well-balanced diets are particularly important during childhood and adolescence when periods of growth and development are most critical (National Health and Medical Research Council, 2003). For example, young people who consume adequate fruits and vegetables are likely to reduce the risk of developing conditions such as coronary heart disease, hypertension, stroke, Type 2 diabetes, osteoporosis and many forms of cancer later in life (Hu et al., 2007; World Cancer Research Fund, 2007). The more immediate effects of diet on youth are as apparent as the long-term ramifications. For instance, iron-deficiency, tooth decay and poor bone health in children and adolescents can be the outcome of nutrient-poor diets (National Health and Medical Research Council, 2003).

Erratic eating patterns among adolescents (e.g., skipping meals) have also been linked to poorer weight maintenance, and overall dietary inadequacy resulting from a lower total daily energy, vitamin and mineral intake (Booth et al., 2006; Nicklas, Myers, Reger, Beech & Berenson, 1998). Beyond the physical effects, skipping meals has also been associated with poorer concentration, attentiveness, cognition, learning and academic performance in the school environment (Story, Neumark-Sztainer & French, 2002).

Key dietary guidelines for Australians recommend adolescents (aged 12–18 years) daily intake should include at least three servings of fruit per day, at least four servings of vegetables per day, lean red meat three to four times per week, and three to five servings of dairy foods per day. Additionally, foods and drinks that contain large amounts of fat, salt and added sugar should be consumed in small amounts or not at all (National Health and Medical Research Council, 2003).

2.3.1.3 Sedentary Behaviour

Sedentary behaviours are primarily sitting or lying behaviours (e.g., involving TV/DVD viewing, computer use or travelling in a car) that require low levels of energy expenditure (1.6 Metabolic Equivalent [METs]) (Rey-Lopez, Vicente-Rodriguez, Biosca & Moreno, 2008). There is some evidence to suggest that the adverse health

outcomes associated with sedentary activities are independent of physical inactivity and poor nutrition (Ekeland et al., 2006). However, sedentary behaviour is thought to compound the effects of these other health behaviours because it displaces time spent being physically active, and is thought to increase energy intake due to unhealthy snacking that has been associated with TV viewing (DeMattia, Lemont & Meurer, 2007; Pearson & Biddle, 2011).

A recent review of the health implications of sedentary behaviour revealed sedentariness is associated with poor metabolic function, bone mineral content, vascular health and an increased risk for some cancers (e.g., colon and endometrial cancer) (Tremblay et al., 2010). Among adolescents specifically, screen time has been linked to metabolic syndrome, hypertension and a variety of psychosocial and cognitive problems including reduced self-esteem, lowered academic performance, decreased pro-social behaviour and increased aggression (Katzmarzyk et al., 2009; Owen, Bauman & Brown, 2009; Tremblay et al., 2010; Tremblay, LeBlanc, Kho et al., 2011). Further, there is good evidence to indicate that sedentariness is positively associated with an increased risk for paediatric obesity (Mitchell et al., 2009; Tremblay et al., 2010) and that sedentary behaviours established during childhood are likely to be carried through to adulthood (Viner & Cole, 2005).

Following emerging evidence for the negative health outcomes associated with sedentary behaviours, guidelines have been established that recommend time limitations for electronic media use (typically referred to as screen time). Current guidelines for Australian children and adolescents (Department of Health & Ageing, 2004) are consistent with previously established and internationally recognised recommendations for TV viewing for youth (American Academy of Pediatrics: Committee on Public Education, 2001; Tremblay, LeBlanc, Janssen et al., 2011). According to Australian guidelines, youth between the ages of five and 18 should limit their time spent in small-screen recreation (SSR) (e.g., TV/DVD viewing, computer use and participation in electronic games) to no more than two hours per day (Department of Health & Ageing, 2004). Additionally, the Canadian guidelines recommend limiting sedentary (motorised) transport, extended periods of sitting and time spent indoors during the day (Tremblay, LeBlanc, Janssen et al., 2011).

2.3.2 Behavioural Trends

2.3.2.1 Physical Activity

Despite heterogeneity in methods used to assess physical activity levels among children and adolescents, consistent trends have emerged in the literature. First, many adolescents worldwide are insufficiently active and do not achieve physical activity recommendations (Salmon & Timperio, 2007). For example, findings from a Finnish adolescent study (Tammelin, Ekeland, Remis & Näyhä, 2007) indicated only 23% of boys and 10% of girls met physical activity guidelines of at least 60 minutes per day of MVPA. In the United Kingdom (UK), survey estimates suggest that three of 10 boys and four of 10 girls failed to meet these same physical activity recommendations (Department of Health, 2004).

Second, secular trends show that youth physical activity in clearly defined contexts (i.e., active transport, school physical education and organised sport) has waned over the past 20 to 50 years in several countries including the US, Australia and Sweden (Dollman, Norton & Norton, 2005). There is good longitudinal evidence to support a decline in physical activity with increasing age during the transition from childhood to adolescence (Kimm et al., 2002; Nader, Bradley, Houts, McRitchie & O'Brien, 2008). For example, from age nine to 15 years, Nader and colleagues (2008) reported a substantial decline in average daily MVPA from three hours to 49 minutes for male and female adolescents combined.

Similar trends have been reported for Australian youth. Recent data from the New South Wales Schools Physical Activity and Nutrition Survey (SPANS) indicated that less than two-thirds (63%) of adolescents met national physical activity guidelines (≥ 60 minutes per day of MVPA) (Hardy et al., 2011). Findings from this study also showed an annual decrease of 1.7% in the prevalence of students meeting the physical activity guideline from 2004 to 2010. Norton and colleagues (2001) reported a 1.5% per annum decline in participation rates in organised sport since the early 1980s. Other Australian data have shown a substantial decrease in the use of active transportation to and from school by youth (e.g., walking or cycling). For instance, between 1971 and 2003 the proportion of students aged 10–14 years that commuted to school by walking had

halved from 42.2% to 21.1% and commuting by car for this purpose had increased from 12.2% to 47.8% (van der Ploeg, Merom, Corpuz & Bauman, 2008).

Finally, there is evidence to suggest that gender and socio-economic background are associated with physical inactivity (Hardy et al., 2011; Okely et al., 2008; Taylor et al., 2002). For example, recent findings from the New South Wales SPANS (Hardy et al., 2011) showed the median daily MVPA minutes reported for adolescent girls in Grade 10 (71 minutes) was significantly less than their male counterparts (90 minutes). Additionally, Hardy and colleagues (2011) found the proportion of female (58.1%) and low-SEP (56.1%) adolescents meeting national physical activity guidelines was lower than for males (66.8%) and those of middle- and high-SEP (61.6% and 68.2% respectively).

2.3.2.2 Dietary Behaviour

Similar to physical activity trends, dietary behaviours for both boys and girls typically deteriorate during adolescence (Department of Health and Ageing, 2008; Moreno et al., 2010). Story and colleagues (2002) provide an explanation for this trend, suggesting that increasing autonomy is a major factor, as more meals are consumed away from the family home. In their recent review of dietary habits in adolescents, Moreno and colleagues (2010) reported a number of dietary trends that have been associated with increases in the prevalence of obesity observed in many developed nations. These include an increase in snacking behaviours and the number of meals eaten away from home, and a shift towards higher consumption of fast foods and kilojoule-dense sweetened beverages.

Australian research exploring adolescent dietary behaviours have revealed erratic eating patterns, (particularly skipping meals), a low intake of fruit, vegetables and dairy products and an excessive consumption of soft drinks, fast foods and confectionary (Australian Institute for Health and Welfare, 2007; Hands, Parker, Glasson, Brinkman & Read, 2004; Hardy et al., 2011). Specifically, summary findings from the 2007 Australian National Children's Nutrition and Physical Activity Survey indicated only 1–2% of adolescents (aged 14–16 years) consume the recommended three servings per day of fruit, while only 1–11% met the guideline of four servings per day of vegetables

(Department of Health and Ageing, 2008). More recently, other Australian data showed the proportion of children and adolescents found to consume breakfast daily decreased with age, while adolescent girls and students of low-SEP were more likely to skip breakfast altogether (Hardy et al., 2011). Further, Booth et al. (2006) investigated soft drink consumption by SEP, and found intake was generally higher among youth of low-SEP.

2.3.2.3 Sedentary Behaviour

In recent decades, societal changes, such as an increased availability of electronic entertainment devices, reliance on cars and access to labour-saving devices in the home have resulted in increasingly sedentary lifestyles for adults and youth alike (Lanningham-Foster, Nysse & Levine, 2003). Youth today are more sedentary than were previous generations (Hill, Wyatt, Reed & Peters, 2003) with many spending excessive amounts of time inactive (Salmon, Tremblay, Marshall & Hume, 2011). Indeed, there is evidence to suggest that youth spend more time interacting with electronic media than participating in any other activity during waking hours (Robinson, 2009). Among Australian youth, there is data to indicate that time spent sedentary increases with age, with older adolescents reporting up to 5.8 hours per week day (outside of school hours) and up to nine hours per weekend day sedentary (Hardy et al., 2011). For screen time alone the NSW SPANS found adolescents were spending approximately 2.5 hours per day during the week and more than 4.5 hours per day during the weekend in exceeding current recommendations of no more than two hours per day (Department of Health & Ageing, 2004). In fact, the proportion of students not meeting the recommended guidelines increased with age such that two-thirds of year 10 students, compared to one-third of Kindergarten students were participating in more than two hours of daily screen time (Hardy et al., 2011).

In other research, Hardy and colleagues (2007) examined changes in sedentary behaviour specifically among adolescent girls. The findings showed the proportion of leisure time spent sedentary significantly increased from 45% to 63% during the transition from early- to mid-adolescence. Time in sedentary behaviour increased 1.4 and 3.3 hours on weekdays and weekend days respectively, and the larger increases in sedentary-based activities during the weekend were attributable to sitting around

chatting with friends (60 minutes/day), using the computer (37 minutes/day) and watching the TV (34 minutes/day).

2.4 Understanding Physical Activity, Dietary and Sedentary

Behaviours in Adolescents

2.4.1 Correlates of Behaviour

In health behaviour research, correlates of behaviour are identified when significant cross-sectional associations emerge between variables (e.g., personal, social and environmental) and behaviour (e.g., participation in physical activity) (Bauman, Sallis, Dzewaltowski & Owen, 2002). While these relationships do not explain causality of behaviour, they are still useful for generating hypotheses for future studies (Bauman et al., 2002).

The evidence for correlates of physical activity, dietary and sedentary behaviour is provided in Tables 2.1–2.3. Each table identifies major correlates of these three health behaviours for which there has been consistent support in the adolescent literature.

2.4.1.1 Physical Activity

Correlates of youth physical activity behaviour are presented in Table 2.1. Reviews conducted by van der Horst et al. (2007) and Sallis et al. (2000) provide evidence for a range of psychological, behavioural, environmental (social and physical), socio-demographic, family-related and other personal factors in children and adolescents that have been associated with physical activity behaviour. Meanwhile, Biddle and colleagues (2005) reviewed the evidence for physical activity correlates for adolescent girls specifically and reported a variety of psychological, behavioural and social environmental factors, yet found no consistent trends for other environmental factors.

Table 2.1: Correlates of physical activity behaviour

Types of correlates	Specific correlates
<i>Socio-demographic</i>	Age* Gender (male) Ethnicity Socio-economic status*
<i>Genetic and physiological</i>	Genetics Weight status (non-overweight) Motor-skill development
<i>Behavioural</i>	Drug use* and diet Participation in community sport Sedentary behaviours* Time spent outdoors
<i>Psychological</i>	Perceived competence Self-efficacy Perceived barriers* Enjoyment of physical activity Knowledge, attitudes and beliefs about activity Intentions to be active Body image
<i>Socio-environmental</i>	Family and parental support for physical activity Sibling physical activity Serious neighbourhood crime* Neighbourhood density* Access to facilities and equipment

Note. *Inverse relationship

2.4.1.2 Dietary Behaviour

A large number of potential correlates of dietary behaviour have been studied in adolescents. However, consistent evidence is lacking (McClain, Chappuis, Nguyen-Rodriguez, Yaroch & Spruijt-Metz, 2009) and this is perhaps largely due to the wide-ranging types of dietary behaviours that have been examined in cross-sectional studies - including fruit, juice and vegetable consumption, fat in diet, total energy intake, sugar snacking, sweetened beverage and fast food consumption, and dietary fibre (see Table 2.2). In their review of child and adolescent studies, Rasmussen and colleagues (2006) reported socio-demographic, personal and family-related factors were best associated with fruit and vegetable intake. McClain et al. (2009) specifically reviewed the literature for psychosocial correlates of various eating behaviours and found the most consistent positive correlates to emerge were socio-environmental and personal factors. More

recently, Cutler et al. (2011) also found support for socio-environmental and socio-demographic correlates of dietary intake in a large cohort of adolescent girls.

Table 2.2: Correlates of dietary behaviour

<i>Types of correlates</i>	<i>Specific correlates</i>
<i>Socio-demographic/personal</i>	Socio-economic status preference
<i>Behavioural</i>	Family meal frequency Fast food consumption*
<i>Psychological</i>	Intentions to eat healthily
<i>Socio-environmental</i>	Peer support for healthy eating Perceived modelling for healthy eating Parental support for healthy eating Parental consumption of healthy foods Dietary norms Availability and accessibility to healthy food

Note. *Inverse relationship

2.4.1.3 Sedentary Behaviour

Evidence for the correlates of sedentary behaviour in adolescence is not as extensive. While much of the evidence is predominantly for TV-viewing behaviours, more research is needed to examine correlates of other types and total sedentary behaviour (Salmon et al., 2011). Three reviews of correlates of sedentary behaviour in children and adolescents have shown strongest support for socio-demographic factors to be associated with time spent in sedentary activity (Salmon et al., 2011; van der Horst et al., 2007; van Sluijs, Page, Ommundsen & Griffin, 2010) (see Table 2.3). In other research, some evidence for behavioural, socio-environmental and psychological correlates of sedentary behaviour in adolescents has been reported (Ekeland et al., 2006; Roemmich, Epstein, Raja & Yin, 2007).

Table 2.3: Correlates of sedentary behaviour

<i>Types of correlates</i>	<i>Specific correlates</i>
<i>Socio-demographic</i>	Age Ethnicity Socio-economic status* Parental education*
<i>Behavioural</i>	Computer use
<i>Psychological</i>	Depression
<i>Socio-environmental</i>	Parental behaviour TV set in bedroom

Note. *Inverse relationship

In summary, there are a wide range of individual, interpersonal and environmental factors that are associated with physical activity, dietary and sedentary behaviours in adolescents. This evidence is useful for informing prospective research for several reasons. Demographic and behavioural correlates, for example, can help researchers identify groups of youth requiring attention due to a lower adherence to healthful behaviours. Other correlates of behaviour (e.g., psychological, social and environmental) indicate factors that health professionals and interventions should target to improve the quality of habitual health behaviours in adolescents. Further, settings and contexts that are characterised by particular behaviours can also be identified in establishing where and when an intervention may be required (e.g., dietary behaviours during the critical window after school).

2.4.2 Mediators of Behaviour

To date, most of the research exploring the influences of health behaviour has been cross-sectional. Unfortunately, the evidence produced by cross-sectional research is limited because the relationships reported do not predict or explain causality of behaviour or behaviour change (Bauman et al., 2002). No attempt is made to understand how the different variables may be inter-related in explaining behaviour (Rhodes & Nigg, 2011). For this reason, it is important to consider more robust evidence for factors associated with health behaviour. For example, examining theoretical constructs of behaviour in terms of mediation or theoretical model testing can help to improve our understanding of *why* behaviours occur or *what* facilitates behaviour change.

Theoretical models of health behaviour postulate there are underlying mechanisms through which behavioural interventions affect behaviour change. ‘Mediator’ is the term commonly used when referring to these mechanism(s) that operate in varying degrees to facilitate the pathway between an intervention and a behavioural outcome (Bauman et al., 2002). By examining the role hypothesised variables may have in mediating the pathway between an intervention and targeted behavioural outcomes, researchers may establish which components of an intervention contributed wholly or partially to behaviour change. In turn, this provides valuable evidence for supporting or refining theory that can support the design and delivery of more effective interventions.

However, recent reviews have revealed evidence for mediators of physical activity, dietary and sedentary behaviour in adolescents is lacking (Cerin, Barnett & Baranowski, 2009; Lubans, Foster & Biddle, 2008; van Stralen et al., 2011). It has been suggested this lack of evidence has been compounded by the use of mediator measures with unknown, limited or poor psychometric properties. For example, the problematic use of measures with substandard or limited reliability and validity properties by many studies has been noted in the literature (Brown & Summerbell, 2009; Cerin et al., 2009). Moreover, instrument precision is challenged when modified versions of adult measures are employed in child and adolescent studies without prior testing (e.g., Dunton, Schneider & Cooper, 2007), which may compromise the accuracy of conclusions regarding effective mediators of behaviour. Clearly, more research is needed to develop existing evidence for mechanisms of behaviour change in adolescents, and an essential part of this process is the rigorous development and testing of measures used to assess these mechanisms. The available evidence for mediators of physical activity, dietary and sedentary behaviour in adolescents is discussed below.

2.4.2.1 Physical Activity

In their review, Lubans and colleagues (2008) found only seven studies tested for mediators of behaviour change during physical activity interventions in children and adolescents. Among these studies, the theoretical constructs examined for mediation were from a range of theories, including SCT, Transtheoretical Model (TTM), Theory of Planned Behaviour (TPB) and the Health Promotion Model (HPM). Self-efficacy was the most widely examined construct that received the strongest support for its role

as a mediator of physical activity in adolescents (Dishman et al., 2004; Haerens et al., 2007; Taymoori & Lubans, 2008). There was also support for perceived benefits/outcome expectations as a cognitive mediator, and commitment to planning as a behavioural mediator in adolescent girls (Taymoori & Lubans, 2008). However, no support was found for the mediating influence of any of the interpersonal variables assessed (i.e., norms, exposure to models and social support).

More recently, van Stralen and colleagues (2011) reviewed 17 school-based interventions testing for mediators of physical activity behaviour change. SCT and TPB were the theoretical frameworks most cited by the studies reviewed. Once again, the strongest evidence was reported for self-efficacy, while moderate evidence for intention to be physically active was also found (van Stralen et al., 2011). Other indicators for a mediated effect on physical activity behaviour, although not consistent, have included self-regulation, intrinsic motivation, enjoyment, perceived benefits and autonomy support (Chatzisarantis & Hagger, 2009; Dishman, Motl, Sallis et al., 2005; Dishman, Motl, Saunders et al., 2005; Taymoori & Lubans, 2008).

2.4.2.2 Dietary Behaviour

Fewer studies have investigated mediators of dietary behaviour in adolescents resulting in a lack of evidence to form any strong conclusions. In their 2009 review, Cerin and colleagues found only four studies (all school-based interventions) had examined mediators of dietary behaviour change in adolescents. The authors found only two studies detected mediated intervention effects. In the first study, increases in positive attitude towards reducing soft drink consumption and a decrease in habitual consumption of soft drink in adolescent boys explained a reduction of soft drink intake (Chinapaw, Singh, Brug & Van Mechlen, 2008). In the second study, peer and team norms mediated improvements in healthful eating among high school football players (MacKinnon et al., 2001).

In a more recent review, van Stralen and colleagues (2011) did not report any new evidence for mediators of intervention effects on adolescent dietary behaviour. Twenty-four school-based intervention studies for children and adolescents were reviewed, and only indications were found for attitude and habit strength.

2.4.2.3 Sedentary Behaviour

Similarly, there is little evidence for effective mediators of sedentary behaviour change in adolescents. Van Stralen and colleagues (2011) found only three studies had examined hypothesised mediators of intervention effects on sedentary behaviour change in adolescents. All studies focused only on screen-viewing behaviours and no mediated effects were reported. Further, due to the limited number of studies, very few hypothesised mediators of screen-viewing behaviour have been examined (i.e., only attitude, self-efficacy, intrinsic motivation, social norms and habit), meaning that much more work is needed to develop knowledge in this field.

In summary, strong consistent evidence for mediators of physical activity, dietary and sedentary behaviour change in adolescents is not available. Therefore, little is known about the mechanisms underlying behaviour change in this population. Based on the number of studies available, the most established evidence for mediators of behaviour change in adolescents is perhaps for physical activity. Self-efficacy, outcome expectations and intention to be physically active have received the most support for mediation of intervention affects, which suggests that strategies to improve physical activity in this population should target these constructs. However, the variance between studies regarding their theoretical framework, populations (i.e., by age groups and sex), outcomes and types of measures (e.g., self-report leisure time physical activity versus objectively measured MVPA) and methods of mediation analyses employed makes it difficult to form strong conclusions.

The lack of published work reporting effective mediators of health behaviour change in adolescents could be due to a few reasons. First, many studies do not conduct a mediation analysis if a significant intervention effect was not detected on the relevant behavioural outcome (Chinapaw et al., 2008), assuming this is an essential condition for mediation to occur. However, mediation effects can be detected in the absence of a significant intervention effect (MacKinnon & Dwyer, 1993). Second, failure to detect significant mediation effects despite a significant intervention effect on targeted outcomes could be due to poor measurement where instruments with insufficient reliability and validity properties have been used. Null findings for mediated effects could also indicate other mechanisms were responsible for behaviour change.

Clearly, more research in this field is necessary if we are to progress our understanding of the mechanisms responsible for desirable behaviour change in adolescents. This will involve considerable efforts directed at the development and evaluation of more rigorous measures of hypothesised mediators of behaviour, the careful planning of theory-based interventions, and subsequently rigorous tests of theory to help explain how intervention effects were facilitated. The next section discusses in more detail theories of health behaviour, and gives particular attention to the application of theory in physical activity research in adolescents.

2.4.3 Using Theory to Explain Behaviour

2.4.3.1 The Role of Theory

Theories of health behaviour are used to *explain* behaviour and identify strategies to achieve positive health behaviour change (Glanz, Rimer & Viswanath, 2008). Indeed, there is good evidence to show that behaviour change interventions guided by theory are more likely to produce stronger effects than interventions developed without theory (Anderson-Bill, Winett & Wojcik, 2011; Michie & Abraham, 2004; Webb, Joseph, Yardley & Michie, 2010). However, it is also important to recognise that while theory informs practice, practice too provides evidence to inform and refine theory (Glanz et al., 2008). That is, a good understanding of theories of behaviour change and an ability to use them skilfully in research and practice can facilitate the design of interventions that are more likely to achieve desirable behaviour change (Grol, Bosch, Hulscher, Eccles & Wensing, 2007). Conversely, evidence from effective interventions can help strengthen and evolve theory (Cerin et al., 2009). This synergetic feedback loop between intervention and theory is important because there is increasing emphasis on making evidence-informed judgements about the choice of interventions and intervention strategies (Rimer, Glanz & Rasband, 2001). Hence, it is clear the fusion of theory, research and practice is essential in order to advance an understanding of health behaviour.

2.4.3.2 Types of Theory

There are a multitude of theories used to guide research and practice in health promotion. As there is considerable confusion between theoretical perspectives and how they might be applied (Glanz et al., 2008), it can be helpful to categorise theoretical models according to the levels of influence on health behaviour that are addressed. For example, models of *intrapersonal* or *individual* health behaviour can be considered one-dimensional because they focus only on variables within individuals that influence their health behaviour (e.g., knowledge, attitudes and beliefs) (Rimer, 2008). The TTM, TPB, Health Belief Model (HBM) and Theory of Reasoned Action (TRA) are theoretical models of intrapersonal or individual health behaviour.

In comparison, models of *interpersonal* health behaviour recognise two deterministic frameworks that influence human behaviour: individuals and their environment. These theoretical models propose that interpersonal interactions influence individual cognitions, beliefs and behaviours (Viswanath, 2008). The SCT (Bandura, 1986), for example, specifies that this interaction and influence between individuals and the environment is reciprocated - resulting in individual and social change.

Ecological models extend interpersonal and intrapersonal models by advocating that there are multiple levels of influence on health behaviour, and that in order to understand human behaviour the entire ecological system in which the behaviour occurs and develops needs to be taken into account (Bronfenbrenner, 1999). Specifically, these levels of influence include intrapersonal (e.g., biological and psychological), interpersonal (e.g., social, cultural), organisational, community, physical environmental, and policy (Sallis, Neville & Fisher, 2008).

Previous studies examining the mechanisms of physical activity, dietary and sedentary behaviour change in youth interventions have focused almost exclusively on constructs from intrapersonal and interpersonal theories of behaviour change—specifically, the TTM, TPB and SCT (Cerin et al., 2009; Lubans et al., 2008; Plotnikoff, Costigan, Karunamuni & Lubans, 2013; van Stralen et al., 2011). Brief descriptions of these theories are provided below.

Transtheoretical Model

The TTM is a stage-based model of individual health behaviour that incorporates several factors drawn from different theoretical frameworks including the TPB and Social Learning Theory (Prochaska, Redding & Evers, 2008). Originally developed by Prochaska and DiClemente (1982), the impetus for the TTM model arose when behaviour change in smokers attempting to quit their habit were being studied. This theory has now been applied across a broad context of health behaviours, including dietary and physical activity behaviour, safe sex practices and cancer screening behaviour (Prochaska et al., 2008). The TTM posits that behaviour change is a process that develops over time and with progress through a six stages: pre-contemplation, contemplation, preparation, action, maintenance, and termination (see Figure 2.2) (Prochaska et al., 2008).

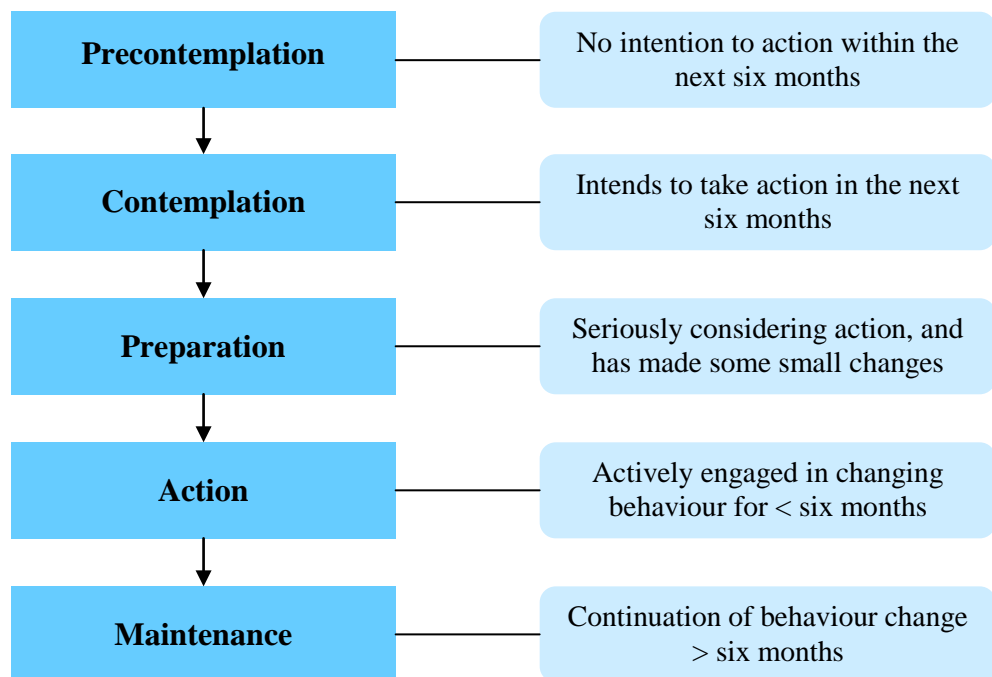


Figure 2.2: Transtheoretical model: Stages of change

(Prochaska et al., 2008, cited in Glanz et al., 2008)

Progression through these stages is not necessarily in a forward linear fashion, but can also be backward or even cyclical. Prochaska and colleagues (2008) explain that the stages of change are used to integrate processes and principles of change. Specifically, there are 10 processes of change that are covert and overt activities people use to progress through the stages of change (e.g., consciousness raising and environmental re-evaluation). The principals of change encompass *decisional balance*, or an individual's weighing of the pros and cons of changing, and *self-efficacy*, which is related to one's confidence to engage in healthy behaviour or temptation to engage in unhealthy behaviour.

Theory of Planned Behaviour

The TPB focuses on a network of theoretical constructs concerned with individual motivational factors that directly and indirectly determine the likelihood of performing a specific behaviour (Montano & Kasprzyk, 2008). The TPB postulates *behavioural intention* is the direct antecedent of behaviour, which in turn is determined by *attitude* towards the behaviour, *subjective norm* associated with the behaviour, and *perceived control* over the behaviour (see Figure 2.3) (Ajzen, 1991). Montano and Kasprzyk (2008) describe how attitude is determined by an individual's beliefs about the outcomes of performing the behaviour (*behavioural beliefs*), which are in turn affected by personal evaluations of those outcomes. Subjective norm is determined by beliefs regarding other's expectations to perform or not perform the behaviour (*normative beliefs*), weighted by an individual's motivation to comply with these expectations. Perceived control is then determined by perceived facilitators and impediments to performing a behaviour (*control beliefs*), weighted by personal evaluation of how much these beliefs will support or inhibit the behaviour (*perceived power*).

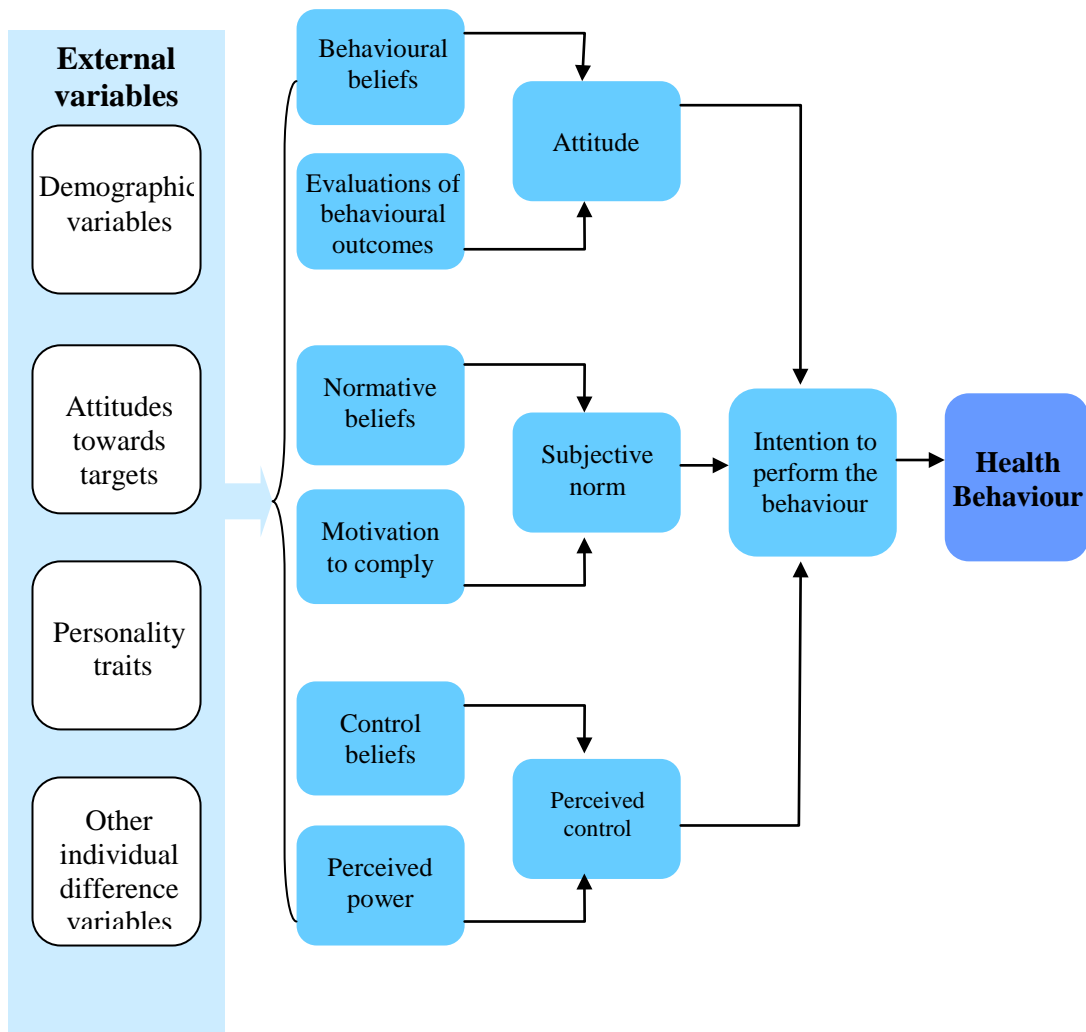


Figure 2.3: Theory of Planned Behaviour
(Montano & Kasprzyk, 2008, cited in Glanz et al., 2008)

Social Cognitive Theory

SCT was first known as *social learning theory*, as it largely focused on how behaviour was shaped via principles of learning within the human social context (Bandura, 1977). SCT has subsequently developed to embrace concepts from sociology, political science and humanistic psychology to advance understanding of functioning and adaptive capacities of groups and societies (Bandura, 1997, 1999). The core of this theory is that human behaviour is the product of the dynamic interplay of personal, environmental and behavioural factors. The term '*reciprocal determinism*' is used to describe how these

factors may affect or be affected by the others. In Bandura's (2004) more recent commentary of the SCT (see Figure 2.4), a core set of determinants of health behaviour and the mechanisms through which these determinants work is specified. These determinants include knowledge, self-efficacy, goals, outcome expectations, and perceived facilitators and impediments to change (see Figure 2.4). Knowledge of the health risks and benefits of a particular health-related habit create the precondition for behaviour change. However, individuals often then require additional self-influences to overcome possible inertia to change.

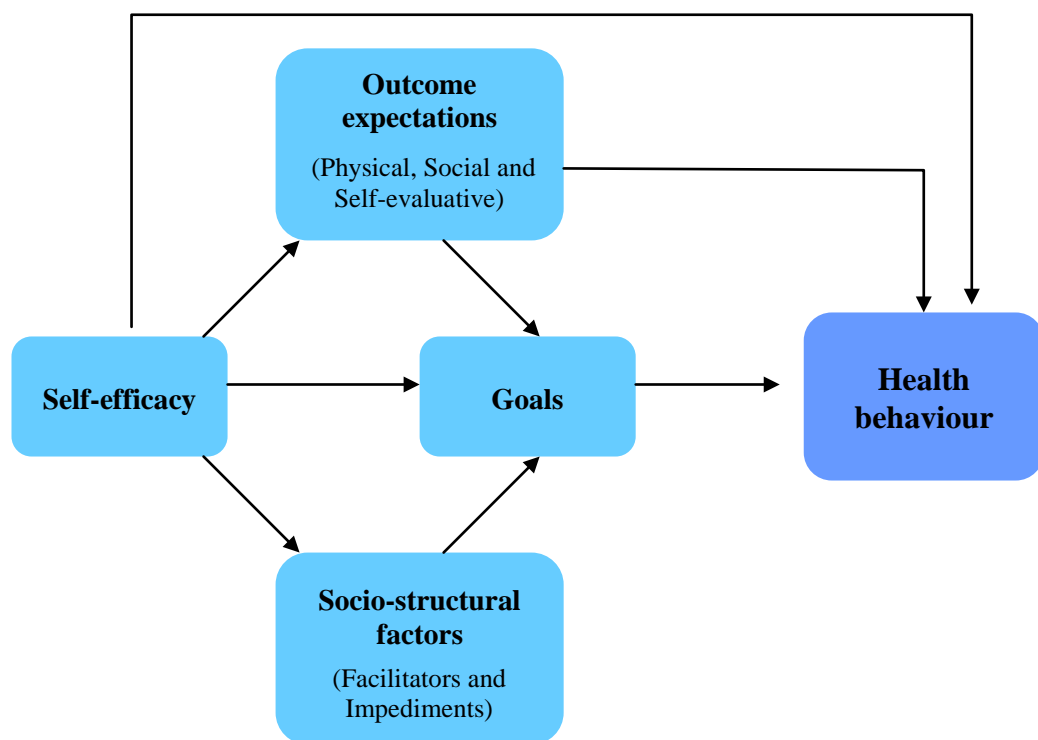


Figure 2.4: Hypothesised structural paths of influence between social-cognitive constructs affecting health behaviour
(Bandura, 2004)

Self-efficacy is regarded as the central determinant of the SCT model because of its effect on health behaviour both directly and indirectly through the other key determinants. Self-efficacy refers to one's belief that they can exercise control over their own health behaviours. Such belief provides an important role in personal change because it provides the platform for motivation and action to achieve change.

Goals are hypothesised to directly influence health behaviour and, when highly valued, enhance motivation to adopt healthy behaviour practices. While goals can be proximal or distal, short-term goals are most effective in enacting behaviour change. Bandura (2004) explains that intentions can be considered proximal goals, since *aiming* to perform a particular behaviour is essentially the same as *intending* to perform a particular behaviour.

Outcome expectations encompass the anticipated beneficial and detrimental outcomes of a health behaviour that can be physical, social and self-evaluative. In the SCT, the outcomes expected for a behaviour are hypothesised to directly and indirectly influence behaviour through *goals*. The physical outcomes can include the pleasant and negative effects of adopting a health behaviour, and the related material losses and gains. The expected social outcomes relate to interpersonal relationships and how significant others may reinforce or discourage future displays of a behaviour. Meanwhile, self-evaluative reactions can also regulate personal behaviour, such that people behave in ways that give them self-satisfaction and self-worth, then conversely refrain from behaving in ways that evoke feelings of self-dissatisfaction.

Finally, *facilitators* and *impediments* to health behaviour encompass the perceived, social or structural factors that may encourage or obstruct behavioural change. In SCT, facilitators and impediments are hypothesised to determine the one's goals. In summary, the relationships between the SCT determinants are operationalised such that individuals who are highly efficacious, tend to expect more favourable outcomes for their efforts, over more likely to overcome barriers and have stronger commitment to the goals they set.

While the few theories described here have been used extensively in health behaviour research in the last 15 years (Glanz et al., 2008), it should be noted that other theories such as self-determination theory (SDT) are gaining momentum. Trends during this period have also seen a shift from the preoccupation with individual level constructs in behavioural research to socio-ecological approaches (e.g., in the physical activity domain) (Rhodes & Nigg, 2011) indicating a growing interest in how the environment shapes behaviour.

In summary, theoretical models of health behaviour can be grouped according to the levels of influence on health behaviour that are addressed. Lower-level influences emphasise individual factors (e.g., psychological). Mid-level influences address the interaction between individuals and their social environment. Higher-level influences consider the environmental, structural and policy contexts of behaviour that are beyond individual control (Glanz et al., 2008). For behaviours in which individual action is required, individual-focused theories can be effective for guiding health promotion strategies (Brewer & Rimer, 2008). However, some theorists argue that most behaviour is beyond the individual and conscious control (e.g., Gollwitzer, 1999), and have dismissed these theories arguing they do not take into account the complexity of factors that influence health behaviours. It has been suggested that models of interpersonal health behaviour, such as the SCT, offer the critical cross-level link between intrapersonal-focused health behaviour theories and the macro-level models such as socio-ecological theories that provide a more holistic perspective of health behaviour influences (Viswanath, 2008).

Regardless of their differences, strengths and weaknesses, many theories of health behaviour have made positive contributions to health behaviour research. It has been suggested that the suitability of a theory is dependent on units of practice, such as individuals, groups and organisations (Glanz et al., 2008), and that the process of selecting a suitable theory should begin by identifying the nature of the problem to be addressed and the goal to be achieved (Sussman & Sussman, 2001), not with choosing a theoretical framework because it is interesting, common or currently in vogue.

2.4.3.3 Testing Theory to Explain Adolescent Behaviour

Theoretical models of health behaviour specify relationships among critical constructs that interact to predict or explain patterns of behaviour (Rhodes & Nigg, 2011). Therefore, evaluating the explanatory power of theoretical models can provide a more rigorous and comprehensive test of theory than examining theoretical constructs alone as correlates or mediating variables. Testing the utility of theoretical models is important for several reasons. Foremost, the validity of applied theory to predict or explain behaviour can be examined. This evidence can then inform decisions about the

use of constructs within the proposed model or the use of theory within its entirety. Subsequently, the development and refinement of theory can occur through the removal of constructs without use, or alternatively theory augmentation may involve adding new constructs to create integrated theoretical models (Rhodes & Nigg, 2011). Acquired evidence can then be used to inform theoretically based interventions to support the design and delivery of more effective programs.

Despite this knowledge, there is little published research for testing the explanatory power of theoretical models to explain physical activity, dietary and sedentary behaviours in youth. It appears most of the evidence available is from the physical activity domain and even then, this evidence is limited (Plotnikoff et al., 2013). Plotnikoff and colleagues (2013) recently performed a review and meta-analysis of key social-cognitive theories (i.e., TPB, TTM, SDT, SCT and HPM) to explain physical activity behaviour in adolescents. Among the 23 studies that were reviewed, TPB was the most commonly tested model in adolescents (12 studies), and results of the meta-analysis revealed that most of the variance in physical activity remains unexplained. Only three studies had tested models based on SCT. The authors noted an over-reliance on cross-sectional designs, and hence it was suggested that future research needs to adopt more rigorous and applied theory tests using longitudinal and experimental studies. This point has been previously supported by Rhodes and Nigg (2011), who argue that since interventions and behaviour change are largely the focus of theory-based research, 'the move to analyses of change via intervention methodology or longitudinal studies of natural change is vital' (p. 118). In their review, Plotnikoff and colleagues (2013) also reported the almost exclusive use of self-report measures of physical activity for tests of theory, and emphasised the need for future tests to employ objective measures of behaviour. This is because self-report measures have questionable validity and reliability due to social desirability bias and young people's inability to recall their behaviours accurately (Chinapaw, Mokkink, van Poppel, van Mechelen & Terwee, 2010).

Clearly, a considerable amount of work remains to be done to advance theory in this field. Specific studies testing the utility of social-cognitive theories to explain adolescent physical activity are described in Chapter 6. Directions for future research are also discussed in this chapter.

2.5 Review of Behavioural Interventions to Prevent Obesity in Adolescents

There is strong consensus in the literature for continued research to improve the effectiveness of obesity prevention interventions in youth (Brown & Summerbell, 2009; Thomas, 2006; Waters et al., 2011). More specifically, the latest Cochrane review for obesity prevention interventions in children and adolescents revealed the majority of interventions targeting adolescents have only achieved modest changes in body composition and health behaviours (Waters et al., 2011). Recent reviews of obesity prevention interventions in children and adolescents have indicated several limitations and challenges that need to be addressed to increase the evidence base and advance the field. This section describes the strengths and weaknesses of relevant studies to date and identifies opportunities for further investigation.

2.5.1 Study Designs

Recent reviews of interventions to prevent obesity in children and adolescents have revealed a number of design limitations, which suggest that findings should be interpreted with caution (Thomas, 2006; Waters et al., 2011). RCTs are regarded as the gold standard for evaluating interventions because treatment bias is minimised or avoided (Schultz et al., 2010). Even so, the latest Cochrane review for obesity prevention studies in children and adolescents revealed that a proportion of interventions were non-RCTs indicating a high risk for selection bias, which may affect the outcomes of the study (Waters et al., 2011). For example, some studies have selected intervention sites based on existing programs, which may have confounded the results (e.g., Harrison, Burns, McGuinness, Heslin & Murphy, 2006).

There is a need for more intervention studies in youth to follow the Consolidated Standards of Reporting Trials (CONSORT) guidelines when designing and reporting intervention effects (Salmon, Booth, Phongsavan, Murphy & Timperio, 2007; Waters et al., 2011). These guidelines are important to ensure adequate study design in avoiding biased estimates of treatment effects, and to support transparency of methods when reporting study protocols and findings (Schultz et al., 2010). Small sample sizes, resulting

in underpowered statistical analyses are an additional concern. The latest Cochrane review revealed the majority of adolescent interventions included small sample sizes, thus limiting their power to detect significant changes in the targeted outcomes (Waters et al., 2011).

Finally, the majority of youth interventions to date have been evaluated over a short duration (i.e., ≤ 6 months) (Brown & Summerbell, 2009; Jones et al., 2011; Waters et al., 2011). Very few studies in adolescents have evaluated interventions lasting 12 or more months, and even fewer have reported post-intervention follow-up of outcomes (Waters et al., 2011). Exceptions include the Trial of Activity for Adolescent Girls (TAAG) study which involved a three-year intervention (Webber et al., 2008), and a two-year physical activity and healthy eating program in middle school-aged students (Haerens, Deforche, Maes, Cardon et al., 2006; Haerens, Deforche, Maes, Stevens et al., 2006), yet neither study included post-intervention follow-up of outcomes. Conversely, the Dutch Obesity Intervention in Teenagers (DOIT) and New Moves studies reported follow-up effects, yet the duration of both interventions was ≤ 12 months (Neumark-Sztainer et al., 2010; Singh, Chinapaw, Brug & van Mechelen, 2009).

Considering the current lack of evidence, there is an important need for studies to evaluate longer-duration interventions (≥ 12 months) *and* for evaluation designs to include extended reporting of intervention effects after intervention completion. Long-term evaluations are essential for several reasons. First, while the sustainability of successful intervention effects can be established, the distal impact of intervention effects can also be determined, which is particularly relevant if impact appears small over the term of the intervention but may be magnified in the longer term (Jones et al., 2011). A recent meta-analysis demonstrated that trials in youth lasting ≥ 6 months (compared to shorter-trials) and reporting post-intervention effects (verse in-treatment effects) yielded larger effects on BMI (Kamath et al., 2008).

2.5.2 Participants

The most recent Cochrane review for obesity prevention studies in children and adolescents reported on 55 controlled-trials (minimum duration 12 weeks) and found only eight studies (15%) were conducted in adolescents (mean age 13 to 18 years) with the

majority targeting children ($n = 37$; mean age six to 12 years) (Waters et al., 2011). Similarly, Brown and colleagues (2009) found only 13 of 38 school-based studies designed to prevent paediatric obesity were conducted in secondary schools with the majority targeting children in primary and pre-school settings. A lack of research in adolescents is compounded by heterogeneity in study methodologies, which has made it difficult to form strong conclusions regarding the most effective interventions to prevent obesity in this group (Brown & Summerbell, 2009; Thomas, 2006; van Sluijs, McMinn & Griffin, 2008). Clearly, much more work in this field is needed in adolescents.

Further, obesity prevention research in children and adolescents has been criticised for a lack of studies targeting the most vulnerable youth (Thomas, 2006). It has been suggested that interventions should differentiate on the grounds of sex, ethnic background, weight and SEP in targeting groups requiring priority attention (Hardy et al., 2011; Olds et al., 2010; Stamatakis et al., 2010). However, many interventions adopt a ‘one-size-fits-all’ approach to obesity prevention programs that do not help the most ‘at-risk’ individuals. For example, the Kiel Obesity Prevention study (KOPs) demonstrated a home-based dietary intervention was effective in reducing the incidence of overweight in high-SEP children, but not among low-SEP children (Plachta-Danielzik et al., 2007). In comparison, the ‘Challenge!’ study was a successful intervention that targeted obesity prevention among youth of low-SEP (Black et al., 2010). The home/community-based program recruited African-American adolescents living in low-income urban communities and involved a mentorship model to promote physical activity and healthy eating. The program was effective in preventing an increase in participant’s BMI category after two years. Yet, there is a limited body of evidence for intervention effects in low-SEP youth; hence, more obesity prevention research is needed in this high-priority group. Specifically, to date, there have been no obesity prevention trials in Australia that have targeted low-SEP adolescent girls.

2.5.3 Settings

Recent reviews indicate the majority of obesity prevention interventions in children and adolescents have been conducted in the US (Brown & Summerbell, 2009; van Sluijs et al., 2008; Waters et al., 2011). Notably, there is little literature available for obesity prevention research in Australian youth. The variance in socio-cultural and racial

characteristics of study samples between countries can make comparisons and considerations for generalisability difficult. Consequently, more research involving the evaluation of obesity prevention programs in Australian adolescents is needed and will help to identify effective prevention strategies for this at-risk population.

Internationally, there is some good evidence for the efficacy of interventions delivered in school settings (e.g., Simon et al., 2008; Singh et al., 2009). However, intervention effects for programs delivered in the community or family/home setting alone have been less convincing (Brown & Summerbell, 2009; van Sluijs et al., 2008). For example, the Stanford and Memphis Girls Health Enrichment Multi-site Studies (GEMS) were two community-based trials targeting unhealthy weight gain in pre-adolescent African-American girls living in low-income communities (Klesges et al., 2010; Robinson et al., 2010). Both trials were evaluated over a two-year period. No significant positive treatment effects for BMI or behavioural outcomes were detected in either study at the end of the intervention (with the exception of water consumption). In comparison, another two-year intervention involved a successful school-based trial in Belgian adolescents. A physical activity and healthy eating program that incorporated parental support, resulted in significant positive intervention effects for BMI, BMI z-score, daily fat intake and percentage of energy from fat in girls, and school-related physical activity in boys (Haerens, Deforche, Maes, Cardon et al., 2006; Haerens, Deforche, Maes, Stevens et al., 2006).

The advantages of using schools for health promotion are well established. Schools have access to the majority of youth and already have the necessary provisions (i.e., facilities, resources and trained staff) in place for the steady promotion of physical activity and healthy eating (Centers for Disease Control and Prevention, 2011). For numerous reasons, including a lack of financial resource, such provisions and infrastructure may not be as readily available or accessible in other settings.

2.5.4 Intervention Effects

2.5.4.1 Impact of Interventions on Body Composition

The small number of obesity prevention interventions in adolescents and the poor quality of previous studies has prevented strong conclusions being formed regarding effective

strategies. These factors, combined with the challenges of working with adolescents (Steinbeck, Baur & Pietrobelli, 2009) may explain the modest effects typically observed in obesity prevention studies targeting this group (Brown & Summerbell, 2009; Kamath et al., 2008; Waters et al., 2011). A recent meta-analysis of interventions effects in adolescents (age 13–18 years) revealed the pooled effects on BMI were small and non-significant [-0.09kg/m^2 (95% confidence intervals [CI], -0.20 to 0.03)] (Waters et al., 2011). In fact, only three studies in this review were found to report a significant intervention effect on any measure of body composition.

For example, the school-based intervention conducted by Haerens et al. (2006) ($n = 2991$; students in Grade 7 and 8) reported significantly smaller increases in BMI and BMI z -score among an intervention group with parental support compared to both a standard intervention group without parental support and the control group (effects in girls only). More recently, an Australian study, the Choose Health program ($n = 63$; 11 to 19 years), involved a six-month family-based cognitive behavioural lifestyle intervention in adolescents for which significant and sustained improvements (following a maintenance phase) in total body fat mass and percentage fat mass were reported (Brennan, Walkley, Wilks, Fraser & Greenway, 2013). The school-based DOIT study ($n = 1108$; 12.7 years) evaluated an eight-month interdisciplinary physical activity and dietary intervention, which included an adapted curriculum in biology and physical education (PE) classes and environmental-change options (e.g., encouraging schools to offer more PE classes, and advice on changes in and around school cafeterias) (Singh et al., 2009). Results showed there was no intervention effect on BMI; however, the intervention remained effective in preventing unfavourable increases in adiposity after a 20-month follow-up in girls (biceps and summed skin folds) and in boys (triceps, biceps and subscapular skin folds).

2.5.4.2 Impact of Interventions on Behavioural Outcomes

In the adolescent literature, there is some evidence to demonstrate successful intervention effects on physical activity, dietary and sedentary behaviours. The latest Cochrane review of obesity prevention interventions found more studies were able to improve behavioural outcomes than levels of fatness (Waters et al., 2011). Even then, there was much variation in behavioural outcomes between study findings. This may be

explained by the variation in the types of behaviours targeted (e.g., time spent in MVPA versus school-related physical activity) and the measures used to assess behaviour (e.g., self-report versus objective measures). Further considerable variation in strategies used to promote these behaviours means it is difficult to draw strong conclusions about the most effective strategies based on the most consistent evidence. Even so, there is some evidence to suggest that combined physical activity and dietary interventions may be more effective at preventing paediatric overweight in the long term (Brown & Summerbell, 2009). Some of the evidence for positive intervention effects on adolescent health behaviour is reviewed here.

Impact of Interventions on Physical Activity Behaviour

The two-year, school-based intervention in Belgian adolescents focused on increasing daily MVPA to at least 60 minutes by creating more opportunities for physical activity during school breaks/after school hours, varying the types of activities on offer to cater for all abilities, and providing sports equipment packs to supplement school sports equipment (Haerens, Deforche, Maes, Cardon et al., 2006). Further, the program offered a computer-tailored component that provided personalised feedback for students in response to their self-reported physical activity behaviours (based on the TTM framework for stages of change). The second intervention treatment included an additional parental support component involving a computer-tailored intervention for physical activity. Intervention effects were found to differ for males and females. Positive intervention effects were reported for males in both intervention groups for self-reported, school-related physical activity and objectively measured MVPA (accelerometry). However, the outcomes were less beneficial for girls; significant effects were only reported for smaller decreases in light intensity physical activity by both intervention groups relative to control.

Similarly, the Lifestyle Education for Activity Programme (LEAP) intervention was aimed at increasing the percentage of participants ($n = 2744$; 13.6 years) meeting the physical activity guidelines (≥ 60 minutes daily MVPA) (Pate, Ward, Saunders, Dishman & Dowda, 2005). The 12-month, school-based intervention specifically targeted adolescent girls and was designed to change both the instructional practices and the school environment to increase support for physical activity. Strategies involved

changes in the content of physical and health education, gender-tailored PE classes, skill development to support a physically active lifestyle, physical activity role modelling and promotion by school staff, and family- and community-based activities. After 12-months, self-reported vigorous activity was greater in intervention schools than control schools (one or more 30 minute blocks of vigorous activity per day); however, there were no significant differences reported for MVPA or the prevalence of overweight between groups.

In comparison, positive intervention effects reported for the TAAG study were more modest (Webber et al., 2008). The intervention involved a two-year, teacher-directed program followed by a 12-month maintenance phase aimed at increasing opportunities and support for physical activity through environmental and organisational changes. Significant yet modest intervention effects were not detected until after three years following the maintenance phase (1.6 MVPA minutes/day).

Impact of Interventions on Dietary Outcomes

The challenges of achieving desirable dietary change in adolescents appear more difficult, as few obesity prevention studies have reported significant positive dietary changes (Waters et al., 2011). The previously mentioned Belgian study by Haerens et al. (2006) also promoted healthy eating by encouraging fruit, vegetable and water consumption, and reducing soft drink consumption and fat intake. Strategies focused on increasing the availability of cheap or free fruit, offering water at a cheaper price than soft drinks and increasing access to water fountains for drinking. Concurrently, a second intervention treatment adding parent support involved parents attending an interactive meeting on healthy behaviours, receiving information on health behaviours via school papers and newsletters, and participating in a computer-tailored intervention for fat intake. However, the only significant intervention effects were reported among girls for a lower intake of fat and percentage of energy from fat relative to control.

Ebbeling and colleagues (2006) describe strategies during an environmental intervention to reduce the consumption of sugar-sweetened beverages (SSB), including weekly home deliveries of non-caloric beverages for 25 weeks, supportive telephone calls on a monthly basis and refrigerator magnets with messages encouraging participants to think twice

about consuming an SSB. Consumption of SSB was reduced significantly in the intervention group over the study period.

Similarly, the DOIT study targeted SSB consumption as well intake of high-energy snacks (Singh et al., 2009). The intervention included an educational component that addressed the health benefits of reducing SSBs and high-energy snacks, and provided guidelines for achieving desirable behaviour change. An environmental component also provided advice for schools on changes to support a decrease in SSB and high-energy snacks among students. The intervention did produce significant positive effects on the consumption of SSB at eight- and 12-months; however, no effect was reported for high-energy snack intake.

Impact of Interventions on Sedentary Behaviours

The number of obesity intervention studies targeting sedentary behaviours in youth is increasing (Kamath et al., 2008; Salmon et al., 2011). However, much of the available evidence for intervention effects is for children, not adolescents. The findings are largely limited to screen-viewing behaviours (e.g., TV/DVD viewing, computer) and more research is needed to examine strategies for reducing alternative sedentary behaviours and overall sedentary time (Salmon et al., 2011).

In examining the evidence for intervention effects in adolescents, the New Moves study for adolescent girls involved individual counselling sessions using motivational interviewing to improve health behaviours (Neumark-Sztainer et al., 2010). After a nine-month follow-up, intervention girls had decreased their sedentary behaviours compared to control girls by 30 minutes/day. In comparison, the DOIT study aimed to increase awareness to reduce screen-viewing behaviours, yet only reported a significant intervention effect among boys after 20 months (–25 minutes/day) (Singh et al., 2009). The PACE + (Patient-centred Assessment and Counselling for Exercise + Nutrition) intervention assessed sedentary behaviour based on a composite self-report measure including time spent watching TV, playing computer/video games, sitting talking on the telephone, and sitting listening to music (Patrick et al., 2005). At post-intervention, a significant between-group difference was reported for sedentary time owing to a decrease

in the intervention group (−21% and −24% for girls and boys respectively) and an increase in the control group (+ 4.8% and + 2.4% for girls and boys).

2.5.4.3 Measurement Issues

Given the variety of tools used to measure body composition and health behaviours in obesity prevention studies, the quality of outcome measures continues to be an important consideration for intervention design and evaluation. For example, BMI has been criticised for its use to detect adiposity change in youth obesity studies due to a lack of sensitivity to distinguish between fat and fat-free mass (McMurray et al., 2002; Singh et al., 2009) and may indicate body build rather than body fatness (Wright, Parker, Lamont & Craft, 2001). Since the premise of obesity intervention research is to reduce or at least slow an increase in adiposity over time, future studies are urged to include more direct measures of adiposity (e.g., skin fold, dual-energy x-ray absorptiometry (DXA) and bioelectrical impedance analysis) (Singh et al., 2009; Wright et al., 2001).

There is a proportion of studies that fail to report the reliability and validity of their behavioural measures (e.g., Klesges et al., 2010; Peralta, Jones & Okely, 2009). Similarly, some study protocols have described using modified versions of previously validated measures without prior validation of the new measure (e.g., Singh et al., 2009). Given the difficulty of measuring behavioural data, it has been recommended for future research to use measures that have been validated and psychometric properties assessed, to ensure that the data collected accurately and reliably measure the behaviours of interest.

A large number of studies rely on self-report measures of behaviour that again can compromise the accuracy of estimates (e.g., Haerens, Deforche, Maes, Cardon et al., 2006; Singh et al., 2009). Although the most frequently cited advantages of self-report measures of behaviour include the ability to characterise behaviour historically and record behaviour by type and context (Trost, 2007), self-report measures are susceptible to response bias due to social desirability (Dollman et al., 2009). For this reason, future studies may be urged to additionally use objective measures of behaviour where

available (e.g., accelerometry or observation to examine physical activity and sedentary behaviour).

Finally, the latest Cochrane review for obesity prevention interventions in youth revealed that approximately half of the studies reviewed did not report any process evaluation data (Waters et al., 2011). Process evaluation data provide information regarding attendance, implementation and quality assurance of an intervention, which is important for ascertaining the feasibility and acceptability of an intervention, and the potential for dissemination (van Sluijs et al., 2008).

2.6 Summary and Future Directions

In summary, there is some support for obesity prevention interventions in adolescents. However, overall effects have been modest and a lack of methodological quality and consistency (e.g., design, participants, settings, intervention strategies and outcome measures) makes it difficult to generalise about ‘what works’ in this population. Clearly, more research in this field is needed to address design and methodological limitations of previous studies.

Importantly, there is an urgent need for the evaluation of interventions lasting longer than 12-months. Evaluation designs also need to be strengthened by including process evaluation measures, and extending assessment of outcomes to post-intervention follow-up. It has also been emphasised that future interventions need to be targeted towards certain groups who are considered ‘at risk’ for developing obesity (including low-SEP youth). For example, gender and SEP have been identified as moderators of intervention effects in a number of the interventions discussed in this literature review (e.g., Haerens, Deforche, Maes, Cardon et al., 2006; Patrick et al., 2005; Singh et al., 2009). This suggests that different programs are required for males and females and that specific attention should be directed towards youth of low-SEP.

Future studies have also been urged to indicate a theoretical guiding framework (Salmon et al., 2007; Thomas, Ciliska, Micucci, Wilson-Abra & Dobbins, 2004). There is growing emphasis on making evidence-informed judgements about the choice of interventions and

intervention strategies, and the use of theory to guide and evaluate interventions (Michie & Abraham, 2004; Rimer, 2008). This knowledge is critical in advancing our understanding of behaviour change. Indeed, there is good evidence to show that interventions guided by theory are more likely to produce stronger effects than interventions developed without theory (Ammerman, Lindquist, Lohr & Hersey, 2002; Anderson-Bill et al., 2011; Michie & Abraham, 2004).

Finally, there is evidence to suggest that obesity prevention interventions that target multiple health behaviours implicated in unhealthy weight gain may be more effective in preventing overweight and obesity than targeting one health behaviour alone (Brown & Summerbell, 2009). Further, the evidence base for the effectiveness of school-based interventions is strong, but the majority of studies have targeted children in primary schools. Hence, more adolescent studies examining the efficacy of multi-component interventions in the school setting are clearly warranted, and should perhaps additionally explore combined familial components (van Sluijs et al., 2008).

Chapter 3: Social-cognitive Measures Related to Adolescent Dietary Behaviour: Development and Evaluation

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Major Findings

A set of seven social-cognitive measures related to adolescent healthy eating behaviours were developed then examined for reliability and construct validity in an adolescent sample. All measures indicated acceptable-to-excellent internal consistency and test-retest repeatability ($\alpha = 0.65$ to 0.79 ; $ICC = 0.81$ to 0.89). Fit indices demonstrated each model to be an adequate-to-exact fit to the data to indicate acceptable construct validity properties.

3.1 Introduction

There is good evidence to indicate that many adolescents demonstrate poor dietary practices while failing to meet current dietary guidelines and recommendations (Department of Health and Ageing, 2008; Hardy et al., 2011; Moreno et al., 2010). Excessive consumption of energy-dense nutrient-poor foods is a major contributor to weight gain during adolescence (Moreno et al., 2010), highlighting the importance of programs to improve diet quality in this group. Unfortunately, interventions directed at this population have achieved limited success (Ammerman et al., 2002; Summerbell et al., 2005). A poor understanding of the mechanisms of behaviour change has been offered as an explanation for the lack of efficacy in dietary interventions targeting youth (Cerin et al., 2009).

Evidence suggests that health behaviour interventions guided by relevant theory (e.g., SCT and SDT) are more effective in changing behaviour than non-theoretical approaches (Hardeman et al., 2005; Michie et al., 2008). These theories hypothesise that an intervention's effects are achieved through underlying 'mechanisms' or mediators (e.g., self-efficacy or perceived benefits) that operate in varying degrees to facilitate the pathway between an intervention and behavioural outcomes (Glanz et al., 2008). For example, the SCT (Bandura, 1986) postulates that behaviour change is influenced by a complex interaction, referred to as 'reciprocal determinism', which occurs between personal factors, environmental factors, and attributes of one's behaviour itself (Baranowski, Perry & Parcel, 2002).

Testing the validity of theoretical models applied to behavioural interventions allows for the development and refinement of theory, which can support the design and delivery of more effective interventions. However, interventions targeting dietary behaviour in children and adolescents rarely assess the theoretical mechanisms of dietary behaviour change (Cerin et al., 2009). Further, the limited research investigating theoretical mechanisms of dietary behaviour change in youth has been compounded by the use of mediator measures with unknown, limited or poor psychometric properties (Cerin et al., 2009). Consequently, little is known about affective mediators of dietary behaviour change in children and adolescents.

Interventions to improve dietary behaviour in youth are often guided by SCT and there is support for social-cognitive correlates of dietary behaviour in adolescents (Baranowski, Cullen & Baranowski, 1999; Bere, Glomnes, te Velde & Klepp, 2008; De Bourdeaudhuij & Vanoost, 2000). To the authors' knowledge, no previous study has developed and tested a comprehensive range of social-cognitive scales for '*healthy eating*' in adolescents. Establishing the psychometric properties of evidence-based healthy eating scales may contribute to an improved understanding of dietary behaviour by providing a parsimonious framework for the evaluation of interventions. As such, the aim of this current study was to: 1) develop a questionnaire that assessed major constructs from Bandura's SCT that relate to a variety of healthy eating behaviours based on current dietary guidelines (National Health and Medical Research Council, 2003); and 2) evaluate the reliability and construct validity of these measures in an adolescent sample.

3.2 Methods

3.2.1 Development of Scales and Items

A series of qualitative and quantitative processes were used in the development of the scales (Streiner & Norman, 2003). Initially, qualitative methods were employed to develop and refine the scales. A review of the literature was carried out to examine the content and psychometric properties of existing measures of social-cognitive constructs related to adolescent dietary behaviour. Subsequently, a preliminary questionnaire comprising seven scales was developed where each scale was considered to represent a unidimensional construct derived from SCT (Baranowski et al., 2002): *self-efficacy*, *intention* (i.e., proximal goals), *situation* (i.e., perceptions of the physical environment), *behavioural strategies*, *social support* and *outcome expectations* (i.e., perceived benefits) and *expectancies* (i.e., value placed on benefits) relating to healthy eating. In Bandura's (2004) more recent commentary of the SCT, intention is considered a proximal goal.

An important objective was to develop measures that address behaviours, intentions and beliefs regarding *healthy eating*. A definition referent for *healthy eating*¹ as guided by key current dietary guidelines and recommendations for adolescents in Australia (National Health and Medical Research Council, 2003) was provided for respondents in the questionnaire. Although it is acknowledged that other definitions for ‘healthy eating’ could be used, the preventive behaviours included in the referent are based on the best available evidence for key nutrition behaviours that have been linked to ill-health (e.g., Burt, Ekland, Morgan, Larkin & Guire, 1988; Ludwig, Peterson & Gortmaker, 2001).

A specialist panel comprising of four experts in the areas of nutrition, SCT and/or scale development were consulted to review and refine the preliminary scales. The four specialists were asked to a) consider the content validity of each scale by examining how well assigned items contributed to the theoretical conceptualisation of the construct being measured; b) consider the suitability of response options according to the wording of respective items; c) evaluate item comprehension; and d) consider the potential for respondent burden.

Subsequently, a focus group was conducted in the spring of 2009 with an adolescent sample ($n = 10$, age 14.1 ± 0.6 years) that matched the questionnaire’s intended audience. This was for the purpose of reviewing and refining the scales. Participants were consenting students from a non-government school in Grades 8 and 9. A semi-structured interview setting was adopted and digitally recorded where probing was used to examine respondents’ thought processes used in arriving at an answer and interpreting items, instructions sets and response options. Following the focus group and suggested changes made, the scales were returned to the expert panel for further review before the scales were administered to the study sample.

¹ Healthy eating: having at least **three** servings of **fruit** and **four** servings of **vegetables** each day; choosing foods/drinks that are **low in fat** (e.g., fruit, vegetables, reduced fat yoghurt and milk, lean cuts of meat, wholegrain breads); choosing foods/drinks that are **low in added sugar** (e.g., wholegrain breads, water, sugar-free (diet) drinks); carefully considering healthy portion sizes during meals (e.g., avoiding eating until you feel full during meal times).

3.2.2 Scales

Self-efficacy. For the nine-item self-efficacy scale, respondents were asked to rate their confidence in personal ability to choose/eat healthy foods whenever a choice is provided using a six-point Likert-type scale of 1 (*strongly disagree*) to 6 (*strongly agree*). For example, ‘*I find it difficult to choose healthy meals or snacks when I am eating out with friends*’.

Intention. Using a four-point Likert-type scale of 1 (*not at all true of me*) to 4 (*very true of me*), five items assessed intention to adopt healthy eating behaviours. The common stem ‘*In the next three months do you ...*’ provided a time referent to direct respondents to regard their intentions for the short-term future. For example, ‘*... do you intend to eat healthier portion sizes during meals—e.g., not eating until you feel full?*’

Situation. Six items examined an individual’s mental representation of the food available in their home environment. Specifically, items examined the provision of healthy snacks, drinks and the availability of fruit and vegetables. For example, ‘*At home fruit is always available to eat—including fresh, canned or dried fruit*’. A six-point Likert-type scale again examined the respondents’ level of agreement/disagreement with each item.

Social support. Seven items assessed the frequency of social support received from parents for healthy eating using a five-point Likert-type scale of 1 (*never*) to 5 (*always*). A time referent was provided to encourage consideration of supportive behaviours received during the previous three months. For example, ‘*During the previous three months, how often did your parents prepare a healthy home-cooked dinner for you?*’ Some items were modified from a previous *social support for healthy eating* scale (Norman et al., 2010).

Behavioural strategies. The behavioural strategies scale comprised 10 items that assessed the frequency of 1 (*never*) to 5 (*always*) at which various behavioural strategies were employed during the previous three months to reinforce healthy eating. Specifically, various methods for enhancing the enjoyment of healthy eating, setting goals for healthy eating, and self-monitoring eating behaviours were inquired about. For example, ‘*During the previous three months, did you leave food on your plate once you*

felt full?’ One item was modified from an earlier *change strategies for healthy eating* measure (Norman et al., 2010).

Outcome expectations and expectancies. The five-item outcome expectations scale combined new items with modified items from established measures relating to dietary or physical activity behaviours (Dishman et al., 2010; Reynolds, Yaroch, Franklin & Maloy, 2002). The expectations scale assessed beliefs about the physical and cognitive benefits of healthy eating. The expectancies scale provided five corresponding personal evaluations of the importance of each expectations benefit. Respondents rated the expectation statements on a six-point Likert-type scale to indicate level of agreement/disagreement with each item, and rated the expectancy statements on a four-point Likert-type scale of 1 (*not at all important*) to 4 (*very important*) to indicate level of personal importance. For example, ‘*Healthy eating can help me to feel more energetic throughout the day; How important is feeling more energetic to you?*’

3.2.3 Questionnaire Administration

After approval was received from the University Research Ethics Committee, consent was obtained from the Principals of three non-government schools from the Newcastle/Central Coast region of New South Wales for their school’s involvement in the questionnaire’s administration. Consenting secondary school-aged students from predominantly middle-class backgrounds were recruited from these schools to complete a two-week test-retest in the autumn of 2010.

3.2.4 Data Analyses

Using SPSS 17.0, descriptive statistics were obtained for all variables including means (*M*), standard deviations (*SD*) and frequencies (*f*). The proportion of missing data was negligible (0.19%), hence mean substitution was the preferred imputation method employed rather than exclusion methods to manage incomplete data (Olinsky, Chen & Harlow, 2003).

SPSS 17.0 was used to conduct the reliability analyses. For each scale, a one-way analysis of variance (ANOVA) was performed to determine differences between repeat

administrations [Test 2 (T2)–Test 1 (T1)]. To provide a coefficient of individual repeatability the 95% limits of agreement were calculated. Scores for the difference between test administrations (T2–T1) were plotted against the test-retest mean $[(T1 + T2)/2]$ for each individual, after which the range of differences falling within the mean of the differences ± 1.96 standard deviations was calculated (Bland & Altman, 1996). Bivariate correlations between the test-retest difference and mean were also obtained. This ascertained if limits of agreement were consistent throughout the range of measurements, as indicated by a small and non-significant correlation. ICCs provide a measure of rank-order repeatability. For each scale, an ICC score ≥ 0.75 indicates excellent reliability (McDowell, 2006). Cronbach's alpha coefficient was also calculated to estimate internal consistency for each scale, whereby acceptable values are > 0.6 (Sim & Wright, 2000).

Confirmatory factor analysis (CFA) was conducted in AMOS 17.0 to examine model fit for each of the scales. A non-significant chi-square result ($p > .05$) indicates a good fit of the model being examined. However, a rejection of the hypothesised model can be an indication that the chi-square is too sensitive to sample size (Bollen, 1989), implicating the need for additional model-fit indices to be examined. Hence, the following model-fit indices were calculated from T1 data: chi-square index, the root mean error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI) and the comparative fit index (CFI). The RMSEA is generally regarded a principal index in examining model fit (Vanderberg & Lance, 2000), where scores ≤ 0.08 , ≤ 0.06 , and 0.0 , signify acceptable, close, and exact fits, respectively (Hu & Bentler, 1999). To interpret GFI, AGFI and CFI indices, scores ≥ 0.9 , ≥ 0.95 or equal to 1 denote adequate, good and exact fit of the model respectively (Hu & Bentler, 1999). If data showed multivariate non-normality (multivariate kurtosis value represented by a Mardia's coefficient > 3) (Mardia, 1970), the Bollen-Stine bootstrap procedure was employed to examine model fit where bias corrected regression coefficients are reported (Bollen & Stine, 1992).

3.3 Results

3.3.1 Descriptive Statistics

The study sample consisted of 173 secondary school students (age = 13.72 ± 1.24 ; 62% female), with backgrounds comprising Australian (80.3%), European (9.9%), Asian (3.5%), Middle Eastern (1.8%), African (1.1%) and other (3.4%). There were no statistically significant differences between genders for test-retest scores (T2–T1) for any of the scales. Hence, separate analyses by gender were not investigated. Table 3.1 presents results for scale means and standard deviations.

3.3.2 Confirmatory Factor Analysis

Self-efficacy. Preliminary analyses showed the original single-factor *self-efficacy* measure was a poor fit of the hypothesised model and that further refinement was necessary. An iterative process was employed to progressively remove items that were represented by unacceptable factor loadings and were found to contribute poorly to the model-fit indices. The final composite was reduced to seven items, which resulted in an acceptable-to-good fit of the model (see Table 3.2).

Intention. Analyses revealed the initial five-item *intention* measure did not require further refinement. Table 3.2 shows the one-factor model demonstrated good model fit as shown by adequate-to-good fit indices.

Situation. A reduced scale resulted in an improved four-item measure. The removal of two items produced fit indices that were a good or exact fit of the model.

Social support. Model-fit results for the original seven-item measure did not satisfy all criteria. Two items were removed due their negative effect on factor loadings and fit indices. The final model resulted in fit indices that demonstrated an acceptable-to-good fit of the model.

Behavioural strategies. The original ten-item composite provided acceptable fit indices however, four items loaded poorly on the one-factor structure and thus were removed to

provide a more parsimonious measure. The reduction supported validation of the scale's structure where fit indices demonstrated the measure was a good-to-exact fit of the model.

Outcome expectation and expectancy. Preliminary analyses indicated further refinement of the paired six-item *expectation* and *expectancy* measure was required. The removal of one pair of expectation/expectancy items that showed extreme platykurtic kurtosis resulted in considerable improvement in model fit for the expectancy measure. The final five-item expectations structure satisfied most model-fit criteria.

3.3.3 Reliability Analysis

Table 3.2 presents final reliability results. Bland-Altman analyses revealed favourable narrow limits of agreement for each scale (see Figures 3.1 and 3.2). Non-significant bivariate correlations between the test-retest difference and test-retest mean indicated the limits of agreement were consistent throughout the range of measures for all scales. ICC scores for all scales indicated excellent rank-order repeatability ranging from 0.81 (*situation*) to 0.89 (*self-efficacy*, *social support* and *outcome expectancy*). Similarly, the internal consistency reliability of all measures proved adequate; Cronbach's alpha values ranged from 0.65 (*outcome expectancy*) to 0.79 (*situation*).

Table 3.1: Means, standard deviations (SD), item kurtosis values, and Mardia's coefficient of multivariate kurtosis for scales

Constructs	Description	Range (No. items)	T1 (Baseline)			T2 (2 week retest)		
			Mean ± (SD)	Item Kurtosis	Mardia (z)	Mean ± (SD)	Item Kurtosis	Mardia (z)
Self-efficacy	Participants were asked to rate confidence in their ability to adopt and overcome barriers to healthy eating behaviours; scale: 1 = <i>disagree a lot</i> ; 6 = <i>agree a lot</i> . E.g., ' <i>I find it easy to eat at least three servings of fruit each day</i> '.	1–6 (7)	4.07 ± (0.81)	–1.06 to 2.38	4.91*	4.25 ± (0.80)	–1.03 to 1.80	2.53
Intention	Participants were asked to indicate their intention to eat healthily, starting with the common stem 'In the next 3 months do you intend to ...'; scale: 1 = <i>not at all true of me</i> ; 4 = <i>very true of me</i> . E.g., ' <i>... do you intend to choose low-fat foods and drinks whenever you have the choice?</i> '	1–4 (5)	3.11 ± (0.52)	–0.64 to 0.61	4.87*	3.20 ± (0.55)	–0.54 to 0.90	7.15*
Situation	Participants were asked to respond to statements about their mental representation of the physical environment influencing their ability to eat healthy foods; scale: 1 = <i>disagree a lot</i> ; 6 = <i>agree a lot</i> . E.g., ' <i>At home there are healthy drinks available?</i> —e.g., <i>cold water, sugar-free drinks, reduced-fat milk</i> '.	1–6 (4)	5.42 ± (0.56)	–0.16 to 2.57	15.01*	5.43 ± (0.58)	0.03 to 3.83	20.97*
Behavioural strategies	Participants were asked to rate the frequency at which they reinforced their own healthy eating behaviours through setting goals, self-monitoring and strategies for enhancing enjoyment, starting with the common stem 'In the past 3 months how often ...'; scale: 1 = <i>never</i> ; 5 = <i>always</i> . E.g., ' <i>... did you choose reduced-fat options when they were available?</i> '	1–5 (6)	3.24 ± (0.71)	–0.95 to 0.00	–0.02	3.33 ± (0.74)	–0.93 to –0.31	2.08
Social support	Participants were asked to rate the frequency with which family reinforced healthy eating through encouragement, role modelling, and accessibility to healthy foods, starting with the common stem 'In the past 3 months how often ...'; scale: 1 = <i>never</i> ; 5 = <i>always</i> . E.g., ' <i>... did your parents encourage you to eat fruit and/or vegetables?</i> '	1–5 (5)	4.29 ± (0.54)	–0.39 to 6.02	15.17*	4.30 ± (0.59)	–0.69 to 7.29	22.23*

Outcome expectations	Participants were asked to respond to statements about various benefits of healthy eating; scale: 1 = <i>disagree a lot</i> ; 6 = <i>agree a lot</i> . E.g., ' <i>Healthy eating (e.g., not skipping meals) can help to improve my concentration at school</i> '.	1–6 (5)	5.33 ± (0.51)	–0.06 to 4.02	19.05*	5.35 ± (0.49)	–0.67 to 6.54	16.15*
Outcome expectancies	Participants were asked to rate personal value placed on each corresponding outcome expectation item for healthy eating. Scale: 1 = <i>not at all important</i> ; 4 = <i>extremely important</i> E.g., ' <i>How important is improving concentration at school to you?</i> '	1–4 (5)	3.40 ± (0.44)	–0.71 to 1.57	4.32*	3.43 ± (0.45)	–0.70 to 2.18	6.28*

Note: *Where Mardia's coefficient for multivariate kurtosis indicate measures that violate the assumption of multivariate normality (>3), the Bollen-Stine bootstrap procedure is employed to examine model fit.

Table 3.2: Reliability results, model-fit indices and factor loadings

Reliability results					Validity results					
Constructs	R^a	95% LoM	ICC (95% CI)	Cronbach's alpha	$\chi^2 (p)$	RMSEA	CFI	GFI	AGFI	Factor Loadings
Self-efficacy	-0.03	-0.80 to 1.17	0.89 (0.85 to 0.92)	0.70	17.41 (0.04)	0.07	0.94	0.97	0.92	0.40 to 0.73
Intentions	0.08	-0.71 to 0.89	0.83 (0.77 to 0.87)	0.71	9.77 (0.08)	0.08	0.97	0.98	0.93	0.43 to 0.81
Situation	0.04	-0.88 to 0.91	0.81 (0.75 to 0.86)	0.79	0.90 (0.64)	0.00	1.00	1.00	0.99	0.44 to 0.86
Behavioural strategies	0.06	-0.84 to 1.00	0.88 (0.84 to 0.91)	0.75	6.69 (0.67)	0.00	1.00	0.99	0.97	0.43 to 0.75
Social support	0.15	-0.68 to 0.70	0.89 (0.85 to 0.92)	0.71	7.23 (0.20)	0.05	0.98	0.98	0.95	0.47 to 0.70
Outcome expectations	-0.06	-0.70 to 0.74	0.84 (0.79 to 0.88)	0.72	14.67 (0.01)	0.11	0.94	0.97	0.90	0.45 to 0.77
Outcome expectancies	0.03	-0.53 to 0.58	0.89 (0.87 to 0.92)	0.65	14.67 (0.54)	0.00	1.00	0.99	0.97	0.23 to 0.71

Note: ^aBivariate correlations between the difference (T2-T1) and the mean [(T1+T2)/2]; 95% limits of agreement calculated as the range of differences falling within the mean of the difference ± 1.96 SDs; Cronbach's alpha calculated from baseline (T1) data; * $p < .05$; χ^2 , chi-square; AGFI, adjusted goodness-of-fit index; CFI, comparative fit index; CIs, confidence intervals; GFI, goodness-of-fit index; ICC, intra-class correlation; LoM, Limits of agreement; p , probability; RMSEA, root mean square error of approximation.

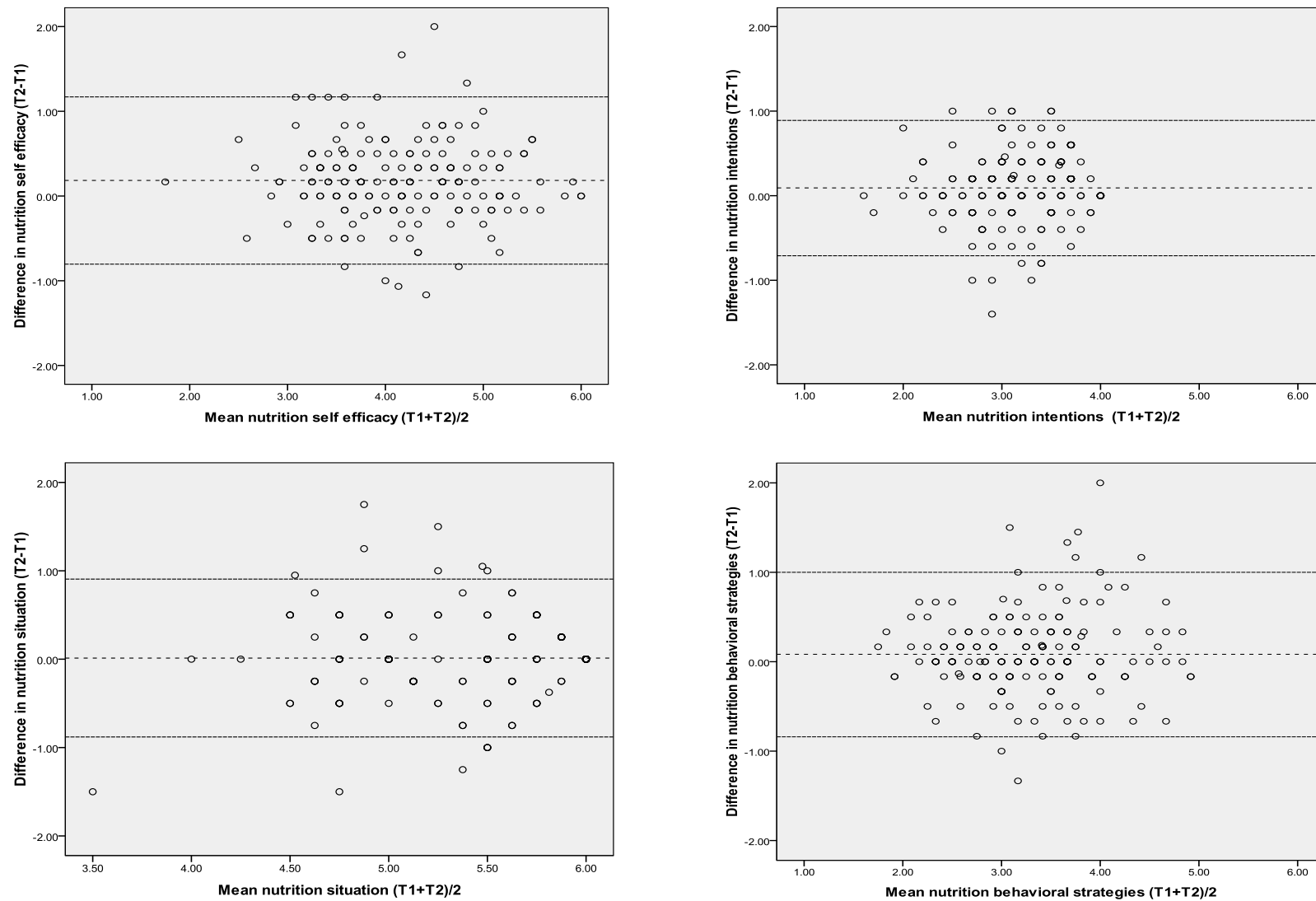


Figure 3.1: Bland-Altman plots of the self-efficacy, intentions, situation and behavioural strategy scores

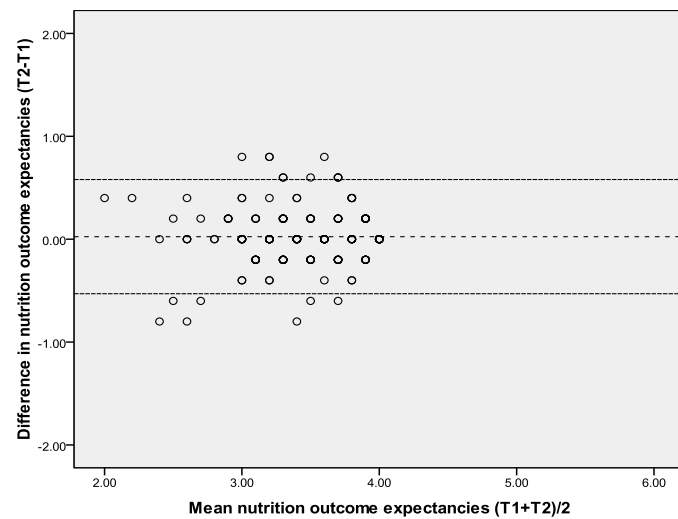
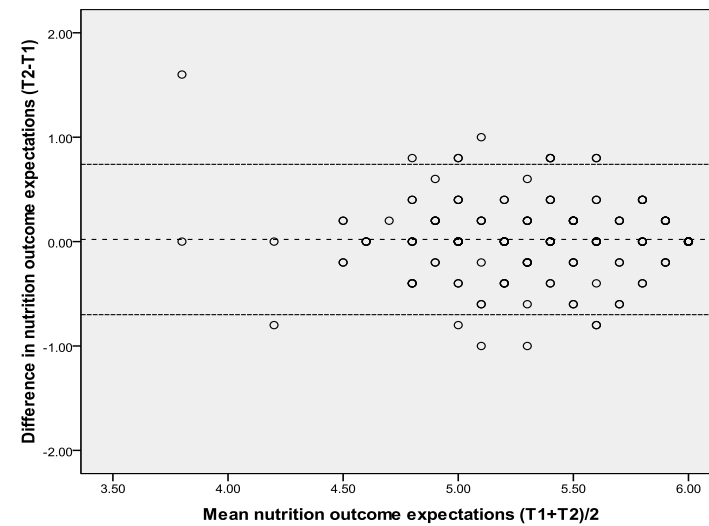
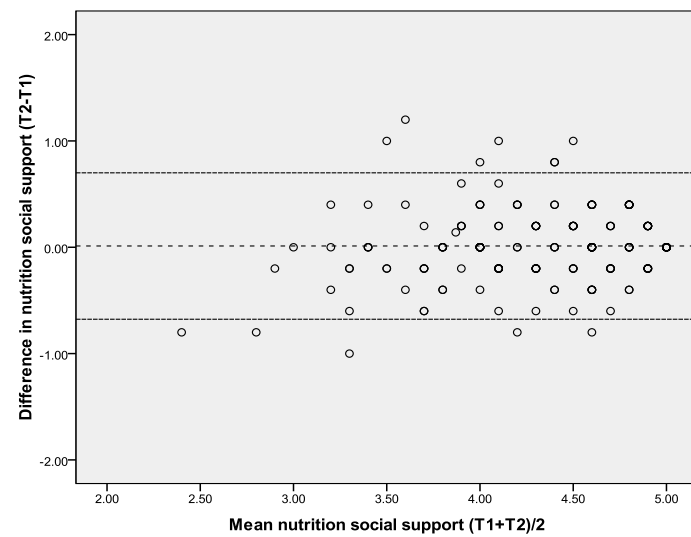


Figure 3.2: Bland-Altman plots of the social support, outcome expectations and expectancy scores

3.4 Discussion

The aim of this study was to develop and evaluate the reliability and construct validity of key social-cognitive measures relating to adolescent dietary behaviours. Few studies have examined the validity of existing health behaviour theories to explain and change dietary behaviour in children and adolescents, and many studies that have examined potential mediators have used instruments with questionable psychometric properties (Cerin et al., 2009). The importance of using quality measures with strong psychometric properties for identifying hypothesised mechanisms of behaviour change has been noted in the literature (Contento, Randell & Basch, 2002).

Overall, the results indicated each of the final scales presented to be a reliable measure showing acceptable construct validity. All measures demonstrated at least acceptable internal consistency reliability ($\alpha > 0.60$) (Sim & Wright, 2000), and excellent rank-order repeatability ($ICC > 0.75$) (McDowell, 2006), and factor analysis revealed the data to be an adequate fit of the hypothesised models. The final scales and their items are presented in Appendix A9.

Comparing the psychometric properties of the current scales with earlier measures of theoretical constructs of dietary behaviour was challenging for a number of reasons. First, previous studies have focused on concurrent and criterion validity by comparing new scales to similar measures or actual dietary intake (e.g., Norman et al., 2010; Sherrill-Mittleman, Klesges, Lancot, Stockton & Klesges, 2009). Alternatively, few studies have examined the construct validity of dietary measures, which is important for establishing the degree to which measures conform to their theoretical construct (Messick, 1995). Second, tests of reliability were often limited to an assessment of internal consistency. Additional reliabilities such as rank-order repeatability (i.e., ICC) and limits of agreement are rarely reported (e.g., Lohse, Cunningham-Sabo, Walters & Stacey, 2011; Sherrill-Mittleman et al., 2009).

Finally, the majority of existing measures have focused on a specific dietary behaviour or intake (e.g., Reynolds et al., 2002; Rossi et al., 2001). For example, adolescent measures reported by Haerens et al. (2007) included several social-cognitive scales for

social support, self-efficacy and perceived benefits that were exclusively related to the consumption of a low-fat diet. These measures provide researchers with a suitable solution for assessment when interested in a specific dietary behaviour or intake. However, they also have limited utility when more than one aspect of dietary behaviour is of interest, in which case respondent burden may become a problem if the administration of several measures is required. For this reason, the current measures presented may provide a suitable solution for researchers interested in a more generalised set of dietary behaviours based on current dietary guidelines and recommendations for adolescents (National Health and Medical Research Council, 2003).

For the current study, strengths include the development of a unique set of social-cognitive scales that are related to healthy eating behaviours in adolescents that are based on current dietary guidelines for this population. These measures provide a parsimonious solution for researchers who are interested in several social-cognitive measures related to general healthy eating behaviours rather than a specific dietary behaviour in intake.

However, there are some limitations that should be noted. First, the sample was relatively homogenous. Further psychometric testing of these measures in more ethnically diverse populations may be warranted. In addition, sample numbers were too small to conduct meaningful sub-group analyses for gender. Second, the tests of validity used in the current study were not extensive. Future researchers are encouraged to test the concurrent and convergent validity of these scales by comparing them with similar validated measures and dietary behaviour. For instance, there is potential to test each scale against percentage of energy intake from core and non-core foods. Core foods include breads and cereals, fruits and vegetables, dairy products and meats, while non-core foods are energy-dense nutrient-poor foods such as fast foods and processed snack foods (National Health and Medical Research Council, 2003). Core foods correspond with the questionnaire's definition referent for 'healthy eating' as per dietary guidelines for children and adolescents (National Health and Medical Research Council, 2003).

Finally, future directions could employ additional factor analytical techniques such that: 1) a cross-validation of the measurement models is examined by employing a multi-group analysis of factorial invariance (e.g., between different socio-economic and ethnic backgrounds); and 2) a longitudinal analysis of factorial invariance of the measurement models is examined (i.e., across time). An assessment of multi-group and longitudinal invariance can determine if differences between groups or over time are the result of true differences in the latent construct being measured (e.g., due to an intervention's effects), or are explained by problematic differences in the measurement properties of the questionnaire(s) due to a change in how respondent's interpret items and their relations.

3.5 Conclusion

Current findings have provided evidence for the reliability and construct validity of seven scales designed to measure SCT constructs relating to healthy eating in adolescents (*self-efficacy, intention, situation, behavioural strategies, social support, and outcome expectations and expectancies*). Collectively, these scales provide a parsimonious solution for researchers interested in understanding dietary behaviours based on current dietary guidelines and recommendations for this group (National Health and Medical Research Council, 2003). As such, the scales presented have utility for identifying potential social-cognitive correlates of healthy eating, mediators of dietary behaviour change, and assessing the validity of theoretical models of dietary behaviour change based on SCT.

Chapter 4: Social-cognitive Measures Related to Adolescent Physical Activity: Development and Evaluation

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Major Findings

A set of six social-cognitive measures related to adolescent physical activity were developed then examined for reliability and construct validity in an adolescent sample. All measures indicated acceptable-to-excellent internal consistency and test-retest repeatability ($\alpha = 0.63$ to 0.79 ; $ICC = 0.82$ to 0.91). Fit indices demonstrated each model to be an adequate-to-exact fit to the data to indicate acceptable construct validity properties.

4.1 Introduction

The health benefits of physical activity for children and adolescents are well documented (Strong et al., 2005). Participation in physical activity contributes to improved musculoskeletal health and the potential for reducing the risk for chronic disease such as Type 2 diabetes, cardiovascular disease, obesity and certain cancers (Biddle, Gorely & Stensel, 2004; Eisenmann, Welk, Ihmels & Dollman, 2007; Lee, 2003; Wang & Dietz, 2002). Further, there is evidence for related psychosocial benefits including improvements in self-esteem and self-concept (Asci, Kosar & Isler, 2001; Walters & Martin, 2000), and a reduction in anxiety and depressive symptoms (Motl, Birnbaum, Kubik & Dishman, 2004; Strauss, Rodzilsky, Burack & Colin, 2001). Yet, unfortunately, there is evidence indicating many adolescents are not sufficiently active and fail to meet physical activity guidelines (Australian Institute for Health and Welfare, 2007; Troiano et al., 2008).

Childhood and adolescence have been identified as critical periods for the establishment of health behaviours that are likely to track into adulthood (Malina, 1996). Hence, interventions targeting the physical activity behaviours of youth are important. However, many interventions directed at this population have been ineffectual or produced only modest outcomes for physical activity behaviour change (Brown & Summerbell, 2009; van Sluijs et al., 2008). Explanations for these findings may be a result of a number of methodological limitations in these studies, including atheoretical interventions, underpowered studies, weak assessment measures, inadequate intervention duration or intensity, poor program compliance or exposure, and a lack of tailored interventions that exclusively target priority groups (Brown & Summerbell, 2009; Salmon et al., 2007; Stone, McKenzie, Welk & Booth, 1998).

The design and development of ineffective programs may also be due to inadequate understanding of the causal mechanisms of physical activity behaviour change specific to children and adolescents (Baranowski & Jago, 2005). Theories of behaviour change (e.g., SCT, TRA and HBM) postulate that there are underlying mechanisms through which intervention effects are achieved (Glanz et al., 2008). By examining the role hypothesised variables (e.g., intentions or social support) may have in mediating the

pathway between an intervention and observed behavioural outcomes, researchers can establish which components of an intervention contributed wholly or partially to behaviour change (Bauman et al., 2002). Despite this knowledge, few studies have examined hypothesised mediators of physical activity intervention effects among children and adolescents (Lubans et al., 2008).

Further, poor quality measures used to assess potential mediating variables has compounded the limited research and evidence for mediators of youth physical activity. In their recent review, Brown and colleagues (2009) revealed the psychometric properties reported for reliability and validity by many measures intended for children and adolescents was substandard or limited implicating the potential for inaccurate conclusions regarding effective mediators and the efficacy of physical activity interventions. Moreover, it was suggested that instrument precision is problematic when modified versions of adult measures are employed in child and adolescent studies without prior testing.

It is clear a stronger evidence base is needed for mediators of physical activity behaviour in developing an improved understanding of ‘what works’ among youth to inform the design of more efficacious interventions. The use of valid and reliable measures that can lead to accurate conclusions regarding effective mediators is an essential component of this process. Hence, the aim of this study is to develop a novel, valid and reliable questionnaire that assesses social-cognitive measures relating to adolescent physical activity behaviours; has utility for population-based research in adolescents; and is suitable for use in adolescent observational and intervention studies to examine potential correlates and mediators of physical activity behaviour. Population specific measures that are current and contextually suitable for the intended audience have important implications for researchers. This is because instrument sensitivity is likely to be improved if measures and their items are deemed appropriate for the particular demographic being investigated (Fitzpatrick, Davey, Buxton & Jones, 1998).

4.2 Methods

4.2.1 Development of Scales and Items

During the initial development of the scales, a series of qualitative processes were employed (Streiner & Norman, 2003). First, a review of the literature reporting the properties of existing social-cognitive measures relating to adolescent physical activity was conducted. A preliminary instrument was then developed, comprising of six scales designed to be unidimensional measures of the following constructs from Bandura's SCT: *perceived self-efficacy*, *situation (perceptions of the physical environment)*, *behavioural strategies (self-control)*, *social support* and *outcome expectations* (perceived benefits) and *expectancies* (value placed on benefits) relating to PA (Baranowski et al., 2002). The SCT purports that behaviour change is influenced by a complex interaction between personal and environmental factors, and attributes of the behaviour itself (Glanz et al., 2008). While many other models of health behaviour are limited to predicting health behaviours, a strength of SCT lies within the provision of predictors and principles that lead to informing, guiding, enabling and motivating individuals to modify their behaviours in promoting good health (Bandura, 2004). This may help to explain why SCT has emerged as a prominent health behaviour model in guiding the development of interventions and examination of mechanisms of health behaviour change in children and adolescents (Cerin et al., 2009; Lubans et al., 2008; Sharma, 2006).

In developing the measures, an objective was to include items that address the significant role that technology plays in the lives of contemporary adolescents (Roy Morgan Research, 2010). As such, several items refer to various modern technologies (e.g., personal music devices, mobile phones and pedometers) that may be used to support participation in physical activity and that research has shown are often accessible to and routinely used by many adolescents today (Australian Communications & Media Authority, 2007; Roy Morgan Research, 2010). The relevance of such technology to youth physical activity has become more apparent in physical activity research in the past decade. Not only has there been an increase in the number of physical activity interventions adopting the use of modern technological

devices (e.g., pedometers and mobile phones) to encourage personal monitoring of physical activity, but there is also growing evidence to support the success of these strategies in promoting physical activity (Lubans, Morgan & Tudor-Locke, 2009; Lubans, Morgan, Callister & Collins, 2009; Newton, Wiltshire & Elley, 2009).

Three experts in physical activity, SCT and scale development were consulted to review the measures and determine content validity. Specifically the experts were asked to a) examine how well each item contributed to the theoretical conceptualisation of each construct; b) examine how well response options supported respective items; and c) evaluate item comprehension and the potential for participant burden (Grant & Davis, 1997).

To further review and refine the scales, a focus group was conducted with 12 secondary school students (age 14.1 ± 0.6 years; females = 58%) in the spring of 2009. Participants were randomly selected from a group of consenting students in Grades 8 and 9 from an independent (non-government) school. A semi-structured interview setting was adopted where probing facilitated the examination of thought processes used in arriving at an answer and interpreting instruction sets and response options. The focus group was digitally recorded and transcribed.

To increase scale sensitivity, the number of Likert-type response options employed by each scale used no fewer than four response options (Anderson & Bourke, 2000). No neutral/uncertain response category was provided for any scale on the basis that this might lower questionnaire reliability through reducing variability (Anderson & Bourke, 2000). As such, scales ensured the provision of weak response categories (e.g., *slightly disagree/agree*) in attracting students who would otherwise prefer a neutral option.

4.2.1.1 Scales

Self-efficacy scale. Self-efficacy was operationalised as an individual's confidence in personal ability to adopt and maintain physical activity behaviours and overcome barriers to physical activity. Eight items were measured on a six-point Likert-type scale of 1 (*strongly disagree*) to 6 (*strongly agree*). For example—'*I find it difficult to be physically active when I have no one to be active with*'. The scale combined original and

modified items from previous scales developed for older children and adolescents (Jago et al., 2009; Motl et al., 2000). For example, Motl and colleagues' (2000) earlier self-efficacy measure included the item '*I can be physically active during my free time on most days no matter how busy my day is*', which was abridged to read '*I can still be physically active even when I've had a busy day*'.

Situation scale. Eight items assessed an individual's mental representation of their physical home/neighbourhood and school environments that may influence their physical activity behaviours. Specifically, items examined how neighbourhood safety and accessibility to facilities and equipment at home and school impact physical activity. For example, '*It is difficult to be physically active in my neighbourhood because of lots of traffic*'. A six-point Likert-type scale again examined the respondents' level of agreement/disagreement with each item. Original items were merged with modified items from an earlier measure intended for older children (Robertson-Wilson, Levesque & Holden, 2007).

Social support scale. Social support was operationalised as various supportive behaviours received from friends and family in the previous three months that encouraged participation in physical activity. For example, '*... did members of your family take you to places where you could be physically active—for example, to the beach, sports training or weekend sport?*' Twelve items examined the frequency of supportive behaviours received using a five-point Likert-type scale of 1 (*never*) to 5 (*always*). Some items were modified versions from a previous scale that examined parent-reported correlates of child and adolescent physical activity (Sallis, Taylor, Dowda, Freedson & Pate, 2002).

Behavioural strategies scale. Eight items examined self-regulation strategies used to reinforce participation in physical activity, including methods used to enhance enjoyment, set goals and self-monitor physical activity behaviours. Two modified items from Dishman's and colleagues' (2010) earlier measure intended for older children and adolescents were included. A five-point Likert-type scale of 1 (*never*) to 5 (*always*) assessed the frequency at which various self-regulation strategies were employed during the previous three months. For example, '*Did you keep track of how much physical*

activity you did—for example, using a pedometer, timer on your phone or by keeping a log book?’

Outcome expectations and expectancies scales. Outcome expectations were operationalised as anticipated physical, social and emotional benefits of being physically active. Eight items were rated on a six-point Likert-type scale of 1 (*strongly disagree*) to 6 (*strongly agree*). For example, ‘*Participation in regular physical activity can help me to manage stress better*’. Some expectation items were modified versions sourced from previous physical activity enjoyment and attitude scales developed for children and adolescents (Motl et al., 2001; Saunders et al., 1997). Five outcome expectancy items provided a corresponding personal evaluation of the benefit identified by each outcome expectation item. Items were rated on a four-point Likert-type scale of 1 (*not at all important*) to 4 (*very important*). For example, ‘*How important is managing stress to you?*’

4.2.2 Questionnaire Administration

Following approval from the University Research Ethics Committee, consent was obtained from the Principals of three non-government schools from the Newcastle/Central Coast region of New South Wales for their school’s involvement in the questionnaire’s testing. Consenting secondary school-aged students from predominantly middle-class backgrounds were recruited from these schools to complete a two-week test-retest in the autumn of 2010.

4.2.3 Data Analyses

Descriptive statistics were obtained for all variables [Means (*M*), standard deviations (*SD*) and frequencies (*f*)] using SPSS 17.0. Since the percentage of missing data was very small (0.02%), mean substitution was the preferred imputation method used to manage incomplete data rather than exclusion methods (Olinsky et al., 2003). Reliability analyses were conducted using SPSS 17.0. To provide a coefficient of individual repeatability, the 95% limits of agreement were calculated (Bland & Altman, 1986). Scores for the inter-trial difference ($T2 - T1$) were plotted against the inter-trial mean $[(T1 + T2)/2]$ for each individual, after which the range of differences falling

within the mean of the inter-trial differences ± 1.96 standard deviations was calculated (Bland & Altman, 1986, 1996). Bivariate correlations between the inter-trial difference and the inter-trial mean were also assessed to establish if the limits of agreement were consistent throughout the range of measurements. Cronbach's alpha coefficient was calculated from T1 (baseline) data to estimate the internal consistency of each scale. Values > 0.6 are considered reliable (Sim & Wright, 2000). Finally, ICCs were calculated to provide a measure of rank-order repeatability. For each scale, an ICC score ≥ 0.75 indicates excellent reliability (McDowell, 2006).

CFA using AMOS 17.0 was used to directly test model fit for each of the scales. The chi-square tests for statistically significant difference between the covariance matrix of the hypothesised model and the observed population variables (Bollen & Long, 1993). While a non-significant chi-square result ($p > .05$) indicates the model being examined is a good fit, it is often too sensitive to sample size and a rejection of the hypothesised model likely results (Bollen, 1989). For this reason, additional measures should be used to examine model fit. Hence, the following model-fit indices were calculated from baseline (T1) data: chi-square index, RMSEA, GFI, AGFI and CFI. In interpreting GFI, AGFI and CFI scores, values ≥ 0.9 , ≥ 0.95 and 1 indicate adequate, good and exact fit of the model respectively (Hu & Bentler, 1999). The RMSEA is widely regarded as a principal index in examining model fit, where scores ≤ 0.08 , ≤ 0.06 , and 0.0, signify acceptable, close, and exact fits, respectively (Vanderberg & Lance, 2000). If data showed multivariate non-normality (multivariate kurtosis represented by a Mardia's coefficient > 3 [Mardia, 1970]), the Bollen-Stine bootstrap procedure was employed to examine model fit and bias corrected regression coefficients are reported (Bollen & Stine, 1992). CFA was also used to examine factor loadings for each item on its latent construct in determining scale homogeneity for each measure. Coefficients ≥ 0.45 are considered fair, while values ≥ 0.55 and ≥ 0.71 indicate a factor loading to be good and excellent respectively (Comrey, 1973).

4.3 Results

4.3.1 Descriptive Statistics

The study sample included 171 secondary school students (age = 13.6 ± 1.2 ; 61% female), comprising 80.1% Australian, 9.9% European, 3.5% Asian, 1.8% Middle

Eastern, 1.2% African and 3.5% other. A one-way ANOVA revealed there were no statistically significant inter-trial gender differences for any of the scales. Hence, separate analyses by gender were not carried out. Scale means and standard deviations are presented in Table 4.1.

4.3.1.1 Confirmatory Factor Analysis

Self-efficacy scale. Preliminary analyses revealed the original eight-item self-efficacy scale to show inadequate model fit and requiring further refinement. An iterative process involving the removal of one item at a time found three items represented unacceptable factor loadings on the model, contributed poorly to model-fit indices and were considered redundant by other similarly worded items seeking the same information. Subsequently, Table 4.2 shows the final composite resulted in a five-item one-factor model where fit indices demonstrated good-to-exact fit, and factor loadings for items ranged from fair (0.45) to excellent (0.70).

Situation scale. Initially, a one-factor model resulted in a poor fit to the eight-item situation questionnaire. Further confirmatory analyses revealed a more robust scale was established when treated as a two-factor model comprising of a home/neighbourhood environment factor and school environment factor. Following the removal of two items that loaded poorly on the home/neighbourhood structure, fit indices significantly improved for the final two-factor model, which demonstrated good fit and comprised item loadings that ranged from fair to excellent for the home/neighbourhood (0.49 to 0.72) and school (0.52 to 0.73) factors respectively (see Table 4.2).

Social support scale. The original 12-item social support scale demonstrated poor model fit when treated as a one-factor model. Analyses supported a two-factor structure as items were categorised to either a *friend* or *family* factor, indicating from whom social support for being physical active was received. Following the removal of two items from each of the family and friend support subscales, the final two-factor model showed an improved and parsimonious fit represented by adequate-to-good fit indices and item loadings that ranged from good to excellent for the friend (0.57 to 0.71) and family (0.62 to 0.73) support factors respectively (see Table 4.2). The final measures comprised four friend support items and four family support items.

Behavioural strategies scale. The original eight items loaded adequately on the one-factor model, however, some fit indices proved less than satisfactory. Two items that contributed poorly to the scale's psychometric properties were removed. The resulting scale showed improved model fit, demonstrating adequate-to-good fit indices (see Table 4.2) and good factor loadings that ranged from 0.55 to 0.70.

Outcome expectations and expectancies scales. Preliminary analyses showed model fit for a paired eight-item expectations and expectancies measure did not satisfy all criteria. The removal of three expectations items, which loaded poorly on the expectations structure, resulted in a refined five-item scale that satisfied most model-fit criteria and comprised good (0.50) to excellent (0.79) factor loadings (see Table 4.2). The removal of the three corresponding expectancy items also improved model-fit indices and factor loadings (ranging from 0.29 to 0.79) for the expectancy scale. Yet, poor values for the RMSEA and some factor loadings persisted, suggesting further refinement was needed. Additional confirmatory analyses revealed the removal of one pair of items, which provided a non-interpretable factor loading (< 0.30) on the expectancy scale, did improve and satisfy all model-fit indices and factor loadings. However, a decision was made to retain the corresponding items because of the content representativeness value.

4.3.1.2 Reliability Analysis

Reliability results for the final questionnaires following item reduction are shown in Table 4.2. Bland-Altman analyses revealed narrow limits of agreement for each of the scales (see Figures 4.1 and 4.2). Non-significant bivariate correlations between the inter-trial difference and inter-trial mean indicated the limits of agreement were consistent throughout the range of measures for all scales, except one (home/neighbourhood situation scale). ICCs indicated very good rank-order repeatability, ranging from 0.82 for outcome expectations to 0.91 for the self-efficacy, family social support and behavioural strategies scales. Meanwhile, internal consistency coefficients were at least acceptable and ranged from 0.63 for the home/neighbourhood situation subscale to 0.79 for the behavioural strategies scale.

Table 4.1: Scales' means, standard deviations (SD), item kurtosis values, and Mardia's coefficient of multivariate kurtosis

Constructs	Description	Range (No. of items)	T1 (Baseline)			T2 (2 week retest)		
			Mean ± (SD)	Item Kurtosis	Mardia (z)	Mean ± (SD)	Item Kurtosis	Mardia (z)
Self-efficacy	Participants were asked to rate their confidence in their ability to adopt and overcome barriers to PA behaviours; Scale: 1 = <i>Disagree a lot</i> ; 6 = <i>Agree a lot</i> . E.g., 'When I'm physically active (e.g., during PE or school sport) I get embarrassed about my fitness or skill level'.	1–6 (5)	4.2 ± (1.0)	–1.09 to 0.11	1.42	4.1 ± (1.0)	–1.08 to 0.12	2.06
Situation ^a	Participants were asked to respond to statements about their mental representation of the home/neighbourhood and school physical environment that may influence their PA behaviour; Scale: 1 = <i>Disagree a lot</i> ; 6 = <i>Agree a lot</i> .							
	(a) Home/neighbourhood example: 'At home I have access to equipment that helps me to be physically active—e.g., bikes, balls, skateboards'.	1–6 (3)	5.0 ± (0.9)		12.63*	5.0 ± (0.8)		
	(b) School example: 'At school, facilities are available during recess/lunch for me to be physically active—e.g., the gym, dance studio, sports equipment'.	1–6 (3)	3.8 ± (0.9)	–0.20 to 6.19		3.7 ± (1.0)	–0.57 to 1.76	6.19*
Social support ^a	Participants were asked to rate the frequency with which friends and family reinforced PA through encouragement, role modelling, and the provision of PA opportunities; Scale: 1 = <i>Never</i> ; 5 = <i>Always</i> .							
	(a) Friend support example: 'In the past three months, how often did you make plans with your friends to be physically active together?'	1–5 (4)	3.1 ± (0.9)		3.38*	3.2 ± (0.8)		
	(b) Family support example: 'In the past three months, how often did your parents buy you equipment that encouraged you to be physically active—e.g., sports clothes, joggers, bike?'	1–5 (4)	3.8 ± (0.9)	–0.89 to 0.81		3.9 ± (0.8)	–0.80 to 0.73	2.69

Behavioural strategies	Participants were asked to rate the frequency with which they reinforced their own PA behaviours through setting goals, self-monitoring and strategies for enhancing enjoyment; Scale 1 = <i>Never</i> ; 5 = <i>Always</i> . E.g., ' <i>IN the past three months, how often did you participate in a variety of physical activities to avoid boredom?</i> '	1–5 (6)	3.2 ± (0.8)	–0.78 to –0.19	1.41	3.2 ± (0.8)	–0.63 to 0.55	3.15*
Outcome expectations	Participants were asked to respond to statements about various benefits of PA; Scale: 1 = <i>Disagree a lot</i> ; 6 = <i>Agree a lot</i> . E.g., ' <i>Participation in regular physical activity helps to improve my fitness</i> '.	1–6 (5)	5.2 ± (0.6)	0.10 to 5.85	14.85*	5.3 ± (0.5)	–0.67 to 8.18	20.08*
Outcome expectancies	Participants were asked to rate personal value placed on each corresponding outcome expectation item for PA.; Scale: 1 = <i>Not at all important</i> ; 4 = <i>Extremely important</i> . E.g., ' <i>How important is improving your fitness to you?</i> '	1–4 (5)	3.2 ± (0.5)	–0.74 to 0.81	2.76	3.3 ± (0.5)	–0.65 to 0.54	3.35*

Note: ^aScale is presented as a 2-factor model; PA, physical activity; PE, physical education; *Where Mardia's coefficient for multivariate kurtosis indicate measures that violate the assumption of multivariate normality (>3), the Bollen-Stine bootstrap procedure is employed to examine model fit.

Table 4.2: Reliability results, model-fit indices and factor loadings.

Reliability results					Validity results					
Constructs	R^b	95% LoM	ICC (95% CI)	Cronbach's alpha	$\chi^2 (p)$	RMSEA	CFI	GFI	AGFI	Factor Loadings
Self-efficacy	0.03	-1.14 to 1.02	0.91 (0.88 to 0.93)	0.69	3.82 (0.58)	0.00	1.00	0.99	0.97	0.45 to 0.70
Situation ^a										
a) Home/neighbourhood	-0.18*	-1.12 to 1.07	0.88 (0.83 to 0.91)	0.63	11.22 (0.19)	0.05	0.98	0.98	0.95	0.49 to 0.72
b) School	0.08	-1.45 to 1.29	0.85 (0.79 to 0.89)	0.65						0.52 to 0.73
Behavioural strategies	-0.03	-0.81 to 0.97	0.91 (0.88 to 0.93)	0.79	15.45 (0.16)	0.07	0.97	0.97	0.93	0.55 to 0.70
Social support ^a										
a) Friend support	-0.12	-1.12 to 1.13	0.86 (0.81 to 0.90)	0.74	27.40 (0.10)	0.05	0.98	0.97	0.93	0.57 to 0.71
b) Family support	-0.12	-0.79 to 1.04	0.91 (0.88 to 0.94)	0.78						0.62 to 0.73
Outcome expectations	0.15	-0.77 to 0.95	0.82 (0.75 to 0.86)	0.75	11.26 (0.05)	0.09	0.97	0.97	0.92	0.50 to 0.79
Outcome expectancies	0.05	-0.54 to 0.72	0.88 (0.83 to 0.91)	0.66	15.74 (0.01)	0.11	0.91	0.97	0.90	0.29 to 0.79

Note: ^aScale is presented as a 2-factor model; ^bBivariate correlations between the difference (T2-T1) and the mean [(T1+T2)/2]; 95% LoM calculated as the range of differences falling within the mean of the difference ± 1.96 SDs; Cronbach's alpha calculated from baseline (T1) data; * $p < .05$; χ^2 , chi-square; AGFI, adjusted goodness-of-fit index; CFI, comparative fit index; CIs, confidence intervals; GFI, goodness-of-fit index; ICC, intra-class correlation; LoM, Limits of agreement; p , probability; RMSEA, root mean square error of approximation.

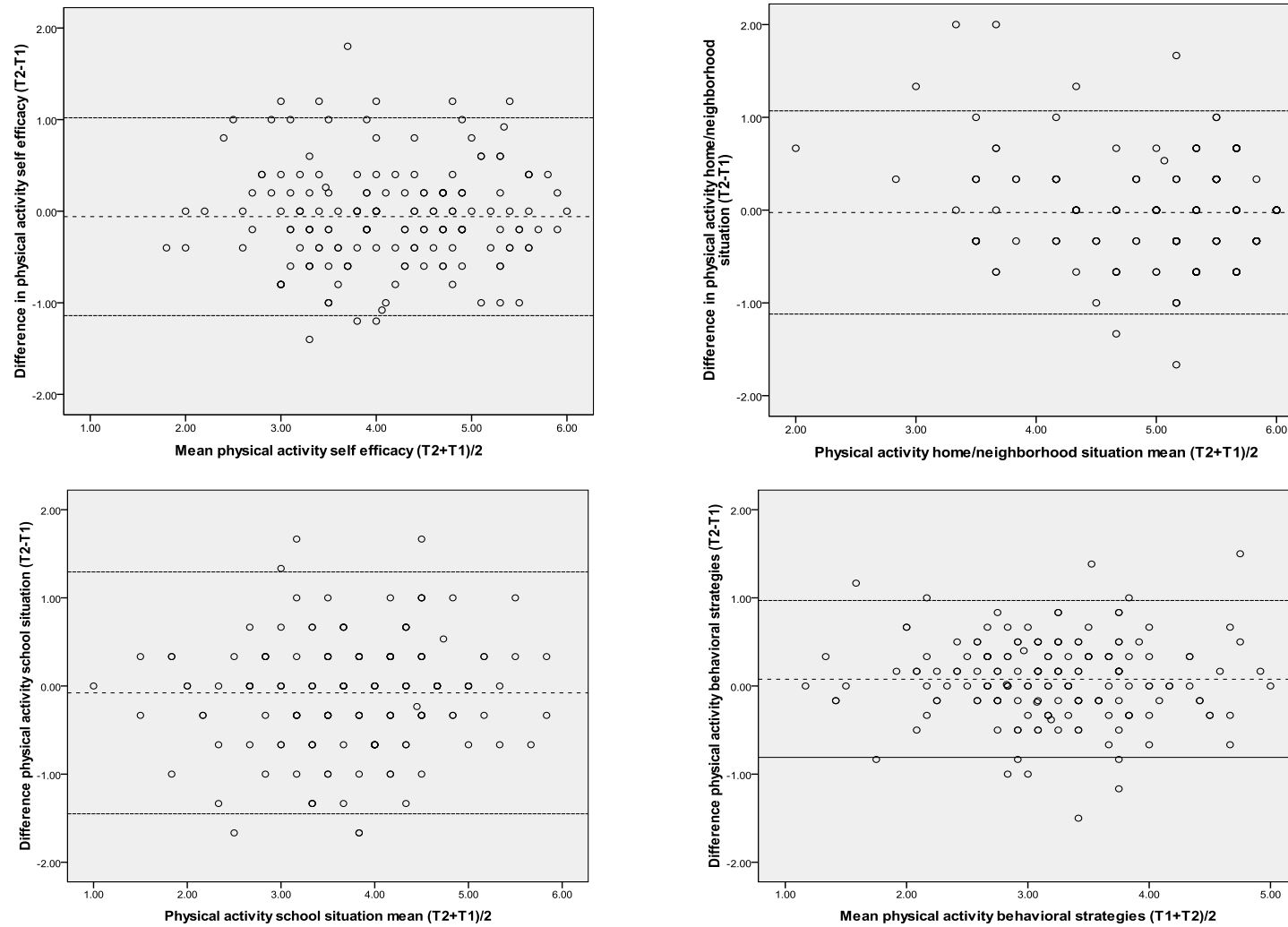


Figure 4.1 Bland-Altman plots of the self-efficacy, home/neighbourhood situation, school situation and behavioural strategies scores

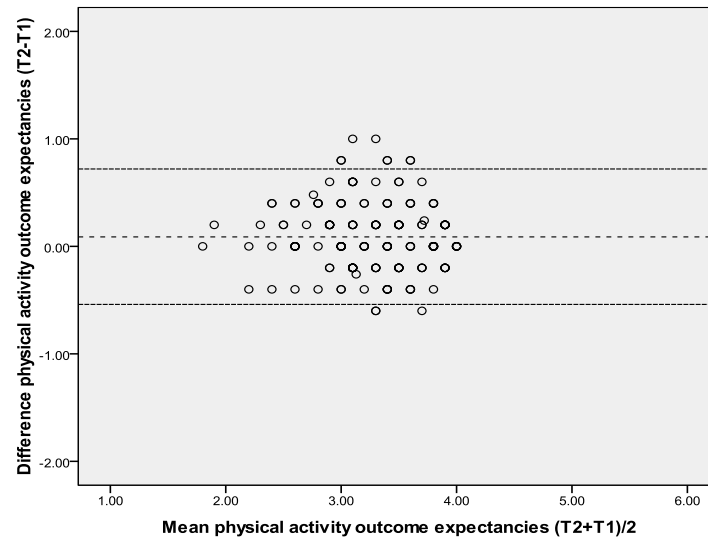
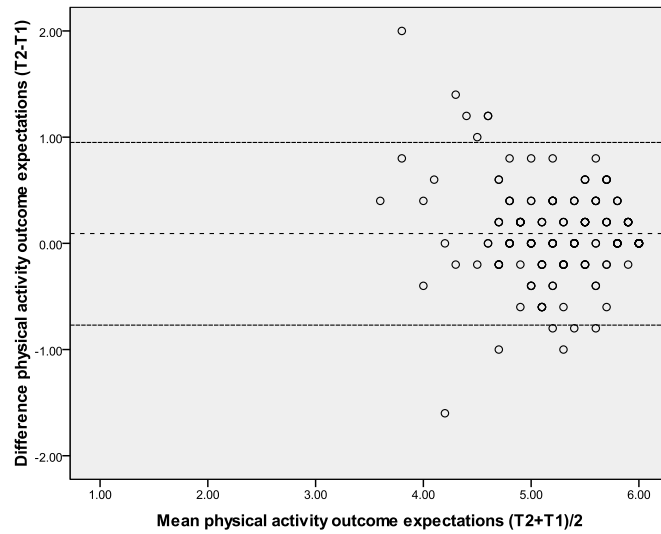
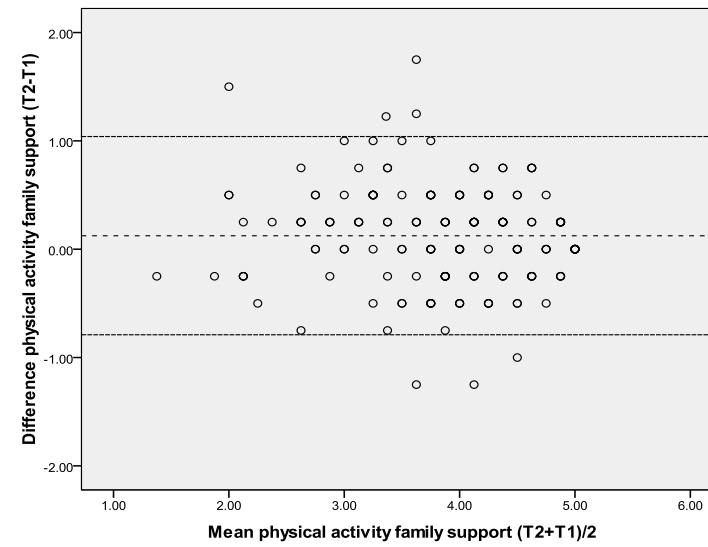
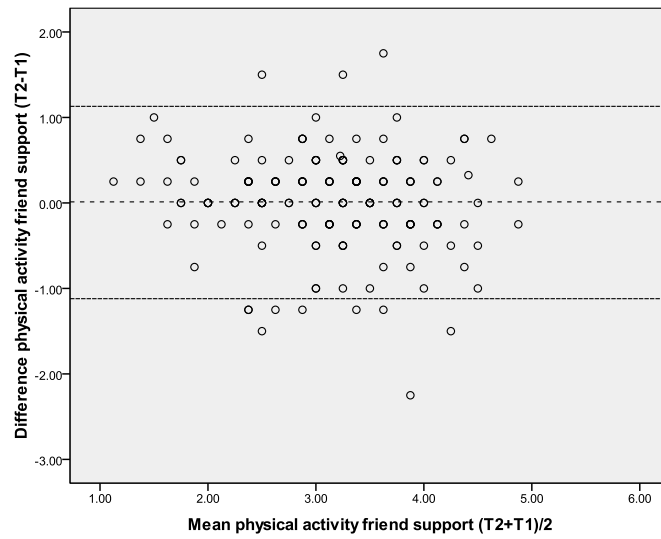


Figure 4.2 Bland-Altman plots of the friend support, family support, outcome expectations and expectancy scores

4.4 Discussion

There is strong support for the influence of social-cognitive factors on the physical activity behaviour of children and adolescents (Lubans et al., 2008; Sallis et al., 2002; Taylor et al., 2002). However, quality measures with strong psychometric properties are needed to improve our understanding of physical activity in these populations. The present study describes the development and evaluation of new scales for assessing social-cognitive measures related to adolescent physical activity. While all scales demonstrated acceptable reliability, CFA was able to establish acceptable construct validity in supporting the scales utility for identifying potential correlates and mediators of adolescent physical activity. The final scales and their items are presented in Appendix A10.

Few comprehensive questionnaires that include several social-cognitive measures have been developed and evaluated in adolescent populations. While a multitude of instruments for assessing social-cognitive influences of physical activity exist, many scales comprise a large number of items (e.g., Jago et al., 2009; Perry, De Ayala, Lebow & Hayden, 2008; Robertson-Wilson et al., 2007; Saelens et al., 2000). This may be problematic for the researcher(s) when more than one measure is of interest. For instance, lengthy questionnaires can be burdensome on respondents, which in turn may negatively impact instrument sensitivity and hence data accuracy (Anderson & Bourke, 2000). As such, improved and more parsimonious social-cognitive measures of youth physical activity are needed.

A unique feature of the scales developed in this study is the inclusion of novel items that assess modern technology's potential influence on the physical activity experiences of adolescents today. For example, in the social support scale, respondents were asked to consider equipment provided by parents that may encourage participation in physical activity and a reference to an iPod (a personal music device) is provided in the prompts that follow the question, '*... did your parents buy you equipment that encouraged you to be physically active? (e.g., sport clothes, joggers, a bike, an iPod for listening to music while being physically active)*'. In a second example, the behavioural strategies scale includes an item that prompts respondents to consider if modern technological devices

may assist personal monitoring of physical activity, ‘... *did you keep track of how much physical activity you did (e.g., by using a pedometer, timer on your mobile phone ...)?*’ To the authors’ knowledge, no similar measures intended for adolescents have included prompts addressing the potential for modern technology to support participation in physical activity. While such a feature supports a more contemporary set of measures, instrument sensitivity may also be improved especially when modern technological devices have become commonplace for many adolescents today (Australian Communications & Media Authority, 2007; Roy Morgan Research, 2010).

In comparing psychometric properties of the presented scales with those reported by similar measures, some challenges were observed. Firstly, while CFA was found to be a popular approach for examining the construct validity of other social-cognitive measures, considerable variation in the model-fit indices reported have made comparisons between studies problematic. Clearly, a set of universally agreed upon standards for examining and reporting model fit need to be established. Regardless, CFA demonstrated each of the current measures to represent good-to-excellent construct validity as shown by acceptable model-fit indices and factor loadings.

Secondly, the author’s found the internal consistency reliability (Cronbach’s α) of earlier measures to be frequently provided, yet few report ICC values to indicate scale stability. Rather, Pearson correlation coefficients are more commonly reported to inform consistency between test and retest scores (Brown et al., 2009). Yet, their use to report stability of data has been regarded inappropriate and flawed because a relation between test and retest scores is merely provided (Baumgartner, 2000). In contrast, ICCs examine agreement, between scores within individuals, and thus are considered a more robust assessment of instrument stability (Thomas, Nelson & Silverman, 2005).

Self-efficacy scale. Bandura (2004) has proposed that self-efficacy is the central determinant of SCT because it influences health behaviour both directly and indirectly through its effect on the other behavioural determinants. Beyond this premise, there is strong empirical support for self-efficacy as a correlate of child and adolescent physical activity (Biddle et al., 2005; van der Horst et al., 2007), and more recently evidence for self-efficacy as a potential mediator of physical activity behaviour change in adolescent intervention studies has developed (Lubans & Sylva, 2009). Our findings support a

valid and reliable measure of self-efficacy. The five-item single-factor structure represents a more parsimonious measure than previous self-efficacy scales that have comprised up to 17 items and three factors (e.g., Jago et al., 2009; Motl et al., 2000; Perry et al., 2008; Saunders et al., 1997).

With regards to CFA, where direct comparisons can be made through reporting of common fit indices (RMSEA and CFI), our findings have improved upon results of several earlier self-efficacy measures (Dishman et al., 2010; Motl et al., 2000; Perry et al., 2008). A further strength of the present self-efficacy scale has seen all items load adequately on the one-factor model. While the authors found few previous self-efficacy measures to report item factor loadings, earlier measures (e.g., Motl et al., 2000) have reported items that have loaded inadequately on the hypothesised model (< 0.45) (Comrey, 1973), without providing argumentative support for doing so. It has been suggested that retaining items that load poorly on a latent construct can compromise questionnaire homogeneity (Comrey, 1973).

Situation scale. There has been increasing interest in the role various aspects of the environment (e.g., physical, social and cultural) may play in facilitating or impeding physical activity behaviour in adolescents (Robertson-Wilson et al., 2007). While the environment is a key construct within SCT hypothesised to influence individual behaviour change, there is strong support for various aspects of the environment, including the physical environment (e.g., access to facilities and opportunities that promote physical activity) to correlate with the physical activity behaviours of children and adolescents (Ferreira et al., 2007; Sallis et al., 2000).

While few previous measures assessing barriers and facilitators of adolescent physical activity have been place-specific (Sallis, Prochaska, Taylor, Hill & Geraci, 1999), the present situation measure examined the *perceived* physical features of specific environments (home/neighbourhood and school) that may promote or impede opportunities for physical activity. While local neighbourhoods and parks have been highlighted in the literature as key locations utilised by adolescents for physical activity (Hoefer, McKenzie, Sallis, Marshall & Conway, 2001), important associations between the school environment and student physical activity levels have also been established (Sallis et al., 2001).

Results indicated the two-factor situation scale to demonstrate favourable construct validity and reliability. While several earlier measures of the physical environment and its relation to physical activity do exist, variability in content does make comparisons of psychometric results perhaps futile. For example, where earlier questionnaires examine physical activity facilitators or impediments of the neighbourhood environment only (Durant et al., 2009; Norman, Sallis & Gaskins, 2005), the current single-factor home/neighbourhood situation scale assesses both the home and neighbourhood environments. Similarly, different information is sourced from Robertson-Wilson and colleagues' (2007) earlier measure of the school environment, which extends the current single-factor school-situation scale by investigating physical features of PE classes, school and intramural sport opportunities. Even so, the present measure may offer researchers a more parsimonious scale that still is capable of examining three physical environments within a concise two-factor structure.

Social support scale. Social support for physical activity is another environmental variable that has received widespread attention for its potential influence on physical activity behaviours. While there is good evidence for parent and peer support to correlate with the physical activity behaviours of children and adolescents (Ferreira et al., 2007; Sallis et al., 2000), the important influence family support may provide has begun to materialise with recent reviews revealing the most efficacious school-based physical activity programs have integrated a familial component (van Sluijs et al., 2008).

The current social support scale comprised a two-factor model assessing *friend* and *family* support for physical activity. Where common fit indices are reported (RMSEA and CFI), present model-fit results are analogous with previous results from a similar social support measure (Dishman et al., 2010). Although stability reliability for the *family* (ICC = 0.91) and *friend support* (ICC = 0.86) subscales were higher than coefficients reported by Norman and colleagues (2005) for an earlier family support (ICC = 0.74) and peer support (ICC = 0.68) measure, a comparison of internal consistency revealed marginal difference between the respective measures.

Behavioural strategies scale. The behavioural strategies scale was found to be reliable measure with good construct validity. Although personal regulation of behaviour through strategy use is hypothesised to be a primary mechanism for behaviour change in several theories of health behaviour, there is little empirical evidence available to support such an assumption. Specifically, very few studies have examined the role self-management strategies may play as a potential mediating variable of physical activity behaviour change in youth interventions (Brown et al., 2009; Lubans et al., 2008) and thus strong conclusions cannot be formed. More research is needed in this area, and valid and reliable measures examining self-management strategies for physical activity are necessary to facilitate this research.

Although the present behavioural strategies measure demonstrated sound construct validity, common model-fit indices (RMSEA and CFI) were marginally inferior to earlier reports for self-management scales that assessed behavioural and cognitive strategies among adolescent girls (Dishman et al., 2010; Dishman, Motl, Sallis et al., 2005). Both prior studies evaluated scales that were adaptations of a measure initially developed for adults (Saelens et al., 2000). The internal consistency reliabilities of our scale compared both favourably (Dishman et al., 2010) and less favourably (Norman et al., 2005) to earlier measures. Although the authors found very few comparable measures to report ICC values, the present measure (ICC = 0.91) did represent stronger instrument stability than Norman and colleagues' (2005) scale (ICC = 0.75). However, while a comparison of psychometric properties have been made, it should be noted that content varies between established measures of self-management strategies for physical activity. For example, Norman et al.'s (2005) single-factor scale examined cognitive and behavioural strategies, and was specifically developed to reflect content of an intended intervention.

Outcome expectations and expectancies scales. Refinement following preliminary analyses resulted in a reduced five-item outcome expectations questionnaire that assessed perceived physical, social and psychological benefits of physical activity, and included corresponding expectancy items examining personal evaluations of each benefit. A primary consideration was to develop a questionnaire that addressed physical activity benefits relevant to adolescents. Contento and colleagues (1992) suggest knowledge of long-term health outcomes do little to motivate adolescent food choices

because the ramifications may be perceived as remote and inconsequential. While the same may be true for adolescent motivations that drive participation in physical activity, the current scale focused more on potential immediate or short-term benefits such as fitness, enjoyment and socialisation rather than potential long-term health implications.

Although most fit indices for the expectations/expectancy subscales were adequate-to-good, weak RMSEA values (> 0.08) suggest further scale refinement may contribute to a more robust model. In particular, one pair of items proved problematic. Although the expectation statement (*Participation in regular physical activity can help me to control my weight better*) loaded adequately on its factor structure (0.55), this was not true for the corresponding expectancy statement (*How important is controlling your weight to you?*), which loaded poorly (0.29) on its respective structure. However, a decision was made to retain the paired items, arguing that the content was particularly relevant to the construct being measured.

Although reliability results demonstrated adequate-to-good internal consistency for the expectancy and expectations subscales respectively, values were poorer than those reported by Dishman and colleagues (2005; 2010) for earlier expectancy measures, yet improved upon values reported in a validation sample (Saunders et al., 1997) for a similar scale. Further, the current questionnaire is a more parsimonious and coherent single-factor measure than Saunders et al.'s (1997) two-factor 16-item belief scale. Although ICC values are not reported by these previous studies to allow a comparison of scale stability, the present expectation and expectancy measures demonstrated a high degree of test-retest reliability (ICC = 0.82 and 0.88 respectively).

The strengths of this study include the development of a contemporary and parsimonious set of scales for researchers interested in several social-cognitive measures related to adolescent physical activity behaviour. The findings conclude the scales demonstrate sound internal and test-retest reliability and construct validity. However, some study limitations should also be noted. The tests of validity used were not extensive. Future researchers are encouraged to test the concurrent and convergent validity of these scales by comparing them with similar validated measures and actual physical activity behaviour. Further, although the study's sample size is comparable to many other validation studies, it may present as a limitation for additional factor

analytical techniques that could be carried out, for example: 1) cross-validation of the measurement models by employing a multi-group analysis (e.g., between different races and populations) of factorial invariance; and 2) testing for longitudinal factorial invariance of the measurement models across time. Focus group participants were adolescents from one low-fee paying independent secondary school and therefore might not be representative of a diverse population of adolescents. Finally, although the racial/ethnic demographics of the study sample were fairly well representative of Australia (ABS, 2008a, 2008b), the sample nevertheless was relatively homogenous; additional testing of the measures in multi-ethnic populations is advised.

4.5 Conclusion

The results of this study provide support for the construct validity and reliability of social-cognitive measures assessing: *perceived self-efficacy*, *situation* (including a home/neighbourhood factor and school factor), *behavioural strategies*, *social support* (including a friend factor and family factor), and *outcome expectations* and *expectancies* relating to physical activity for use among an adolescent population. As such, these scales are suitable for the identification of potential social-cognitive correlates of youth physical activity, mediators of physical activity behaviour changes and the testing of theoretical models based on SCT. Further, this questionnaire provides a contemporary and parsimonious solution for researchers interested in more than one social-cognitive measure relating physical activity behaviour in adolescents.

Chapter 5: A Group Randomised Controlled Trial to Prevent Obesity in Adolescent Girls: Study Protocol and Baseline Findings

Lubans, D. R., Morgan, P. J., Dewar, D. L., Collins, C. E., Plotnikoff, R. C., Okely, A. D., Batterham, M., Finn, T. & Callister, R. (2010). The Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) randomised controlled trial for adolescent girls from disadvantaged secondary schools: Rationale, study protocol, and baseline results. *BMC Public Health*, 10, 652.

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Major Findings

This paper describes the study protocol for the NEAT Girls intervention, and reports baseline information for participant demographics and outcome variables. Three hundred and fifty-seven participants were recruited (13.4 ± 0.4 years) from 12 eligible schools. The majority of participants were born in Australia (97.8%), and identified their cultural background as Australian (85.4%). A high percentage of participants were classified as overweight (26.1%) and obese (16.8%). Among participants with usable accelerometer data, 10.4% met the physical activity recommendations of at least 60 minutes of MVPA per day. A small proportion (11.2%) met daily SSR guidelines of less than two hours per day, and girls reported consuming $168 (\pm 87)$ kilojoules per kilogram per day. There were no statistically significant differences between control and intervention groups at baseline for any of the demographic or outcome variables.

5.1 Introduction

Obesity is a serious health issue and predisposes individuals to an increased risk of morbidity and mortality from conditions such as Type II diabetes, coronary heart disease (CHD), hypertension, hyperlipidemia, and certain cancers (Reilly et al., 2003). Over the last 20 years, the rates of obesity have tripled in developing countries largely due to decreased physical activity and increased consumption of energy-dense foods (Hossain, Kavar & Nahas, 2007). Although there is some evidence to suggest that rates of paediatric obesity in developed countries have levelled off in recent years (Olds et al., 2010), this has not been the case among youth from low socio-economic backgrounds (Dollman & Pilgrim, 2005; Miech et al., 2006; Stamatakis et al., 2010). There is a strong socio-economic gradient in the prevalence of overweight and obesity among youth from developed countries (Dollman & Pilgrim, 2005; Goodman, Slap & Huang, 2003; Miech et al., 2006; Stamatakis et al., 2010) and youth attending schools in disadvantaged areas may be disproportionately susceptible to obesity development (O'Malley, Johnston, Delva, Bachman & Schulenberg, 2007). A recent nationally representative sample of US adolescents found that school socio-economic status (SES) was negatively associated with weight status, even after controlling for individual level SEP (O'Malley et al., 2007).

The treatment of obese youth is a costly and challenging endeavour and prevention strategies are clearly warranted (Allender & Rayner, 2007; Colagiuri et al., 2010). Schools have been a popular setting for the implementation of interventions to prevent obesity as they have continuous contact with students and the necessary personnel, curriculum and facilities to promote physical activity and healthy eating (Brown & Summerbell, 2009). A number of small- and large-scale school-based interventions have been evaluated with varying degrees of success in terms of obesity prevention (Brown & Summerbell, 2009; Katz, O'Connell, Nijke, Yeh & Nawaz, 2008). School-based interventions designed to promote physical activity and healthy eating can be broadly classified as whole-of-school or targeted. Whole-of-school approaches are not directed towards specific individuals and typically involve changes to the school environment, PE and/or relevant physical activity and nutrition (e.g., canteen) policies across the entire school population. For example, the Middle School Physical Activity

and Nutrition (M-SPAN) intervention involved 24 schools and was guided by a socio-ecological model which incorporated policy and environmental changes (Sallis et al., 2003). M-SPAN was successful in producing a greater reduction in self-reported BMI among intervention group boys, but not among girls. More recently, Simon and colleagues (2008) reported successful obesity prevention following the implementation of the Intervention Centred on Adolescents' Physical activity and Sedentary behaviour (ICAPS). Interestingly, ICAPS was a multi-level school-based obesity prevention intervention focused only on the promotion of physical activity and did not have a nutrition component to promote healthy eating. However, in their review of school-based interventions to treat and prevent obesity, Katz and colleagues (2008) suggested that the nutrition component of interventions appeared to be more important for weight reduction than the physical activity component.

Targeted interventions can involve multiple components, but are directed at specific individuals or groups of individuals. Although the whole-of-school approach has the potential to have a positive impact on the health behaviours of a large number of students, this type of intervention may be less effective among those most in need, such as low-active or overweight students (Brown & Summerbell, 2009; Salmon et al., 2007). As certain groups are disproportionately affected by obesity, there has been a call for interventions to be targeted within the school towards specific groups of students and be differentiated on the grounds of gender, age and SES (Stone et al., 1998). For example, physical activity declines during adolescence (Kimm et al., 2002; Nader et al., 2008) especially among adolescent girls from disadvantaged backgrounds, placing this group at an even greater risk of obesity (Miech et al., 2006; Nader et al., 2008).

An advantage of using the targeted approach is that interventions can be tailored to the characteristics of specific groups. A number of school-based interventions have targeted adolescent girls 'at risk' of obesity (Neumark-Sztainer, Story, Hannan & Rex, 2003; Robbins, Gretebeck, Kazanis & Pender, 2006; Schneider-Jammer, Spruijt-Metz, Bassin & Cooper, 2004). For example, New Moves was a school-based intervention for secondary school girls who were overweight or 'at risk' for becoming overweight due to low levels of physical activity (Neumark-Sztainer et al., 2003). Although the intervention was relatively intensive (i.e., four physical activity sessions/week for 16 weeks plus information sessions), it failed to impact upon weight status over the study

period. One possible explanation for this finding is that the intervention did not include a parental component. Parents play an important role in the shaping of their children's weight-related food and activity behaviours (Ventura & Birch, 2008) and may need to be included in multi-level approaches to obesity prevention in youth (Golley, Hendrie, Slater & Corsini, 2011).

This paper provides the rationale, study description and baseline findings from the NEAT Girls program. NEAT Girls is a multi-component school-based intervention that combines a range of evidence-based behaviour change strategies to promote physical activity and healthy eating and prevent obesity among low-active adolescent girls. To the authors' knowledge, NEAT Girls is the first school-based obesity prevention program for Australian adolescent girls from economically disadvantaged secondary schools.

5.2 Methods

5.2.1 Study Design

NEAT Girls is a group RCT investigating the effects of a 12-month multi-component school-based physical activity and nutrition intervention. Assessments took place at baseline (May/June 2010) and will be repeated at 12-months (May/June 2011—end of intervention) and at 24-months (May/June 2012—follow-up) (see Figure 5.1). The design, conduct and reporting of this study will adhere to the CONSORT guidelines (Schultz et al., 2010). Ethics approval for the study was obtained from the University of Newcastle, Australia and the New South Wales (NSW) Department of Education and Training Human Research Ethics Committees. School Principals, parents and study participants provided written informed consent.

5.2.2 Participants

The SEIFA index of relative socio-economic disadvantage was used to identify eligible secondary schools. The SEIFA index (scale 1 = lowest to 10 = highest) summarises the characteristics of people and households within an area and is developed using the following data: employment, education, financial wellbeing, housing stress, overcrowding, home ownership, family support, family breakdown, family type, lack of

wealth (no car or telephone), low-income, Indigenous status and foreign birth. Government secondary schools located in the Hunter Region and Central Coast areas in NSW, with a SEIFA index of ≤ 5 (bottom 50%) were considered eligible for inclusion. From the 26 eligible secondary schools, 18 schools were contacted and 12 schools were successfully recruited.

Eligible study participants were adolescent girls in Grade 8 (2nd year of secondary school) attending one of the 12 recruited schools. PE teachers at the study schools identified and recruited participants. To be eligible for the study, students were considered by their teachers to be disengaged in PE and/or not currently participating in organised team or individual sports.

5.2.3 Sample Size Calculation

Height and weight assessments were used to calculate BMI, which is the primary outcome variable. The primary analysis in this study will be conducted using a linear mixed model. The test of interest will be an F-test with a 1 degree of freedom contrast therefore it was computationally convenient to use the *t*-test to perform the sample size calculations. The sample size calculation was based on the primary end point of 12-months and does not assume adequate statistical power for the 24-month assessments. The between-group difference of 1 kg/m² was based on the results from a similar trial (Robinson et al., 2008), using a BMI standard deviation of 1.5 kg/m² (Singh et al., 2009) and an ICC of .01 (Amorim, Bangdiwala, McMurray, Creighton & Harrell, 2007). Variance estimates were adjusted for clustering as proposed by Murray et al. (2004). In brief, the standard error of the estimate in the usual *t* estimation is replaced by $\sqrt{\frac{2(\hat{\sigma}_m^2 + m\hat{\sigma}_g^2)}{mg}}$ where $\hat{\sigma}_m^2$ is the estimate of the unadjusted subject component of the variance, $\hat{\sigma}_g^2$ is the unadjusted school component of the variance, *m* is the number of subjects per school and *g* is the number of schools per intervention. For the initial a priori estimate of 24 subjects per school to complete the first year of the study, a power of 0.92 was calculated. The minimum sample size recruited was 23, given a 20% dropout; a post hoc power calculation still demonstrates a power of 0.86 to detect the given effect. These calculations are a conservative estimate based on degrees of freedom allowing for a matched design with two covariates.

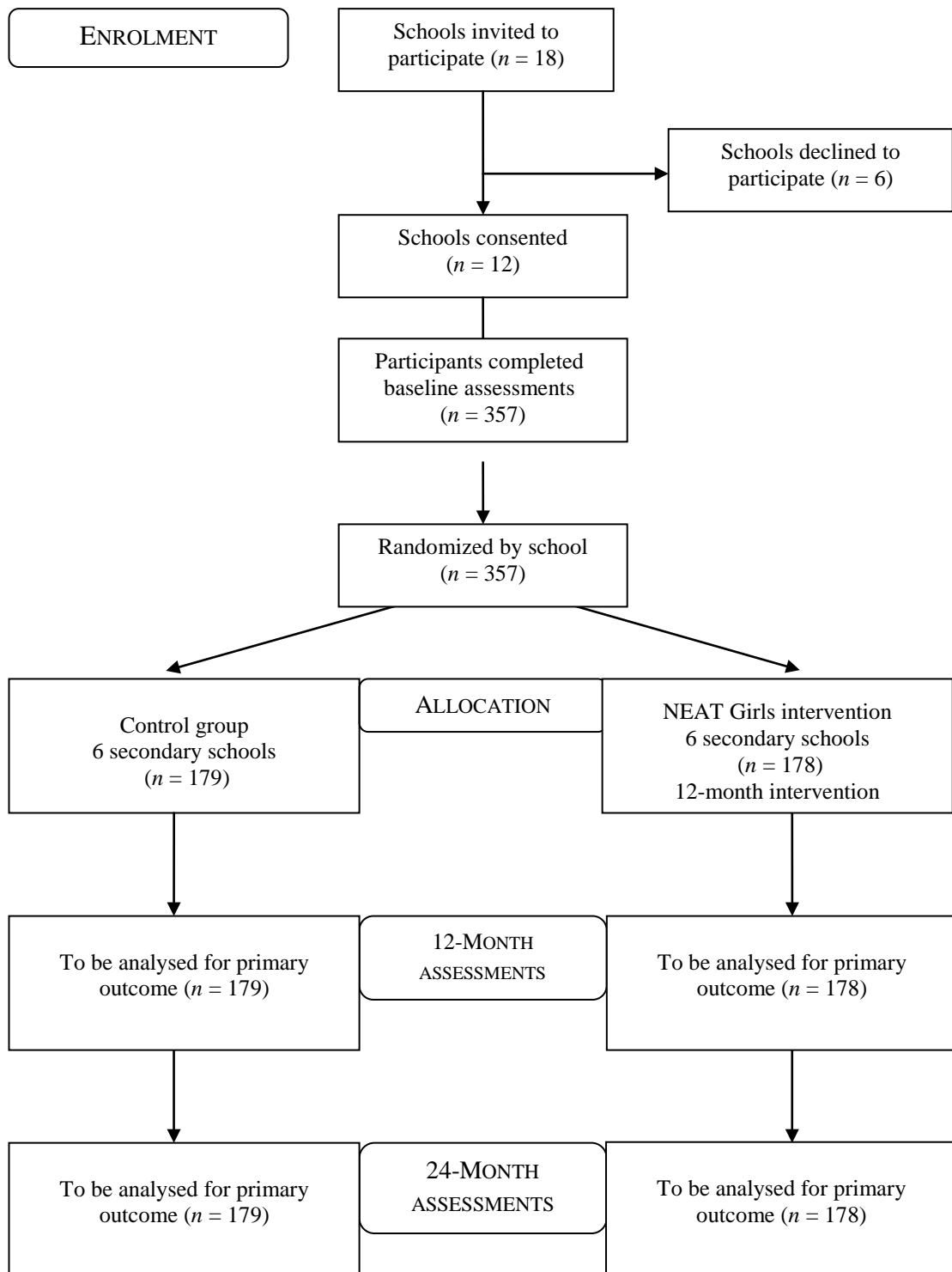


Figure 5.1: Flow of participants through the study

5.2.4 Blinding

Baseline assessments were conducted prior to randomisation by RAs who were blinded to treatment allocation. Where possible, post-test assessments will also be conducted by RAs blinded to group allocation.

5.2.5 Randomisation

Following baseline assessments, the 12 schools were match paired (i.e., six pairs of schools) based on their geographical location, size and demographics. Schools within each pair were then randomised to either the NEAT Girls intervention or a wait list control group by an individual not involved in the research project.

5.2.6 Intervention

NEAT Girls is a multi-component school-based intervention and includes enhanced school sport sessions, interactive seminars, nutrition workshops, lunchtime physical activities, physical activity and nutrition handbooks, parent newsletters, pedometers for self-monitoring and text messaging for social support (see Table 5.1). The intervention combines aspects of our previously successful interventions trialled with adolescents (Lubans & Morgan, 2008; Lubans, Morgan, Callister et al., 2009) and was guided by Bandura's SCT (Bandura, 1986). The intervention components were developed using a taxonomy of behaviour change strategies (Abraham & Michie, 2008) and designed to target potential mediators of physical activity and nutrition behaviour change.

Table 5.1: Intervention components, behaviour change techniques and targeted constructs

Intervention component	Dose	Description	Behaviour change strategy	Targeted construct
1) Enhanced school sport sessions	40 x 90 minutes	School sport sessions will be delivered by teachers and for the first 10 weeks involve an information component (10–15 minutes) and a PA session (75–80 minutes). The information component will address PA and nutrition recommendations, benefits and behavioural strategies. Teacher-directed PA sessions will include a range of lifetime physical activities organised into four-week units. Activities will include resistance training using elastic tubing devices, circuit training, boxing style fitness, Zumba® dance, yoga, skipping rope activities, pedometer activities and a mini-Olympics.	<ul style="list-style-type: none"> • Prompt specific goal setting • Information on consequences • Prompt intention formation • Provide instruction • Barrier identification • General encouragement • Graded tasks 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Self-efficacy • Physical self-perception • Intentions
2) Interactive seminars	3 x 30 minutes	Participants will attend three interactive seminars delivered by members of the research team. Interactive seminars will revise key PA and nutrition recommendations and behavioural strategies to support the student-directed implementation of the lunchtime activities.	<ul style="list-style-type: none"> • Provide information about behaviour health link • Prompt self-monitoring of behaviours • Plan social support or social change • Prompt barrier identification 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Self-efficacy • Intentions
3) Nutrition workshops	3 x 90 minutes	Students will participate in three nutrition workshops delivered by APDs that will provide dietary information and focus on the preparation of inexpensive healthy meals. The activities are planned to develop lifetime nutrition skills that facilitate healthy weight maintenance, including interpreting nutritional information on food labels, recipe modification and preparation, energy balance and kilojoule concept.	<ul style="list-style-type: none"> • Information on food and nutrition • Model or demonstrate the behaviour • Graded tasks 	<ul style="list-style-type: none"> • Outcome expectations • Self-efficacy • Intentions

4) Lunchtime PA sessions	30 x 30 minutes	Student-directed PA sessions involving a range of lifetime physical activities. These sessions will complement the activities offered in the enhanced school sport sessions. In addition, participants will be encouraged to recruit and instruct Grade 7 students in a range of lifetime physical activities.	<ul style="list-style-type: none"> • Model or demonstrate the behaviour • Graded tasks • Prompt identification as a role model 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Physical self-perception • Self-efficacy
5) PA and nutrition handbooks	10 weeks	Participants will be provided with PA and nutrition handbooks. The handbooks will include 10 weeks of information and home challenges designed to promote PA and healthy eating for parents and participants.	<ul style="list-style-type: none"> • Provide information about behaviour health link • Prompt self-monitoring of behaviours • Plan social support or social change 	<ul style="list-style-type: none"> • Self-efficacy • Social support • Outcome expectations • Intentions
6) Parent newsletters	1 x school term (4 in total)	Parents of study participants will be provided with newsletters describing the study progress and detailing information designed to encourage support of their children's PA and healthy eating behaviours in the home environment.	<ul style="list-style-type: none"> • Provide feedback on performance • Plan social support or social change • General encouragement • Provide information about behaviour health link 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Self-efficacy
7) Pedometers	9 months	Participants will be provided with pedometers and encouraged to initiate goal setting and self-monitoring behaviours. Participants will also be given pedometer challenges to complete over the holiday periods.	<ul style="list-style-type: none"> • Prompt self-monitoring • Prompt specific goal setting 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Self-efficacy
8) Text messaging	1 x week (40 weeks) 2 x week (10 weeks)	Students will be sent weekly and twice weekly text messages encouraging them to be physically active and eat healthily. Text messages will also provide strategies to overcome barriers to PA and healthy eating. Students without mobile phones will receive these messages via email.	<ul style="list-style-type: none"> • Plan social support or social change • General encouragement • Provide information about behaviour health link • Barrier identification 	<ul style="list-style-type: none"> • Outcome expectations • Social support • Self-efficacy

Note: APD = Accredited practising dietitians; PA = physical activity.

The intervention is focused on the promotion of low-cost lifetime and lifestyle physical activities and will be delivered over four school terms (i.e., 12-months) at no cost to the school or students. Lifetime physical activities are those that may be easily carried over into adulthood because they generally need only one or two people to participate. Examples include aerobics, jogging, walking, resistance training, swimming and tennis (Ross, Dotson, Gilbert & Katz, 1985). Lifestyle physical activities are those performed as part of everyday life, such as walking to school and climbing the stairs. In many Australian secondary schools, extra-curricular/co-curricular programs are often delivered off campus and may require payment to participate. Consequently, the cost of school sport activities has been identified as a barrier to participation among some students (Lubans, Morgan & McCormack, 2011). The enhanced school sport sessions (60–80 minutes) will be delivered by teachers and involve a range of activities such as elastic tubing resistance training, Yoga, Pilates, Zumba®, power walking, skipping choreography and boxing fitness. The sessions are organised into four-week units and the sequencing of activities is selected by the students. For example, girls may choose Zumba for four weeks followed by four weeks of Pilates.

The NEAT Girls intervention is based on 10 key physical activity and nutrition messages (see Table 5.2). For the first school term, the enhanced school sport sessions include an information component (10–15 minutes) delivered by cooperating teachers from the study schools that integrates the 10 key health messages. The three interactive seminars will be delivered by members of the research team and will reinforce the NEAT Girls physical activity and nutrition messages. The weekly lunchtime physical activity sessions will complement the enhanced school sport sessions and be organised and delivered by the girls participating in the study. The physical activity and nutrition handbook includes 10 weeks of information and home challenges designed to promote physical activity and healthy eating among parents and study participants.

Table 5.2: NEAT Girls physical activity and nutrition messages

<i>Study week</i>	<i>Physical activity and nutrition message</i>
Week 1	<i>Be active in any way you can</i>
Week 2	<i>Aim to eat fruit and vegetables every day</i>
Week 3	<i>Be active with friends and family</i>
Week 4	<i>Eat a healthy breakfast every day</i>
Week 5	<i>Reduce your sitting time during school lunch breaks, after school and on the weekends</i>
Week 6	<i>Monitor your portion sizes during dinner and eat at the dinner table</i>
Week 7	<i>Identify excuses for not being active</i>
Week 8	<i>Drink more water and swap sugary drinks for sugar-free drinks</i>
Week 9	<i>Keep track of your physical activity using a pedometer diary</i>
Week 10	<i>Reduce your junk food snacks</i>

Accredited Practising Dietitians (APDs) will deliver three nutrition workshops in the study schools. These workshops will focus on providing dietary information and strategies designed to develop lifetime nutrition skills that facilitate the maintenance of a healthy weight (e.g., food label reading, recipe modification, energy balance, measuring kilojoules and appropriate portion sizes and the preparation of inexpensive healthy snacks and meals).

Participants will be provided with pedometers to encourage physical activity goal setting and to use during school holidays for assigned physical activity challenges. Pedometers will also be used for self-monitoring and to remind participants of the importance of incidental physical activity and the contribution of non-exercise activity thermogenesis to weight control (Levine, Eberhardt & Jenson, 1999).

Study newsletters will be sent to parents at four periods over the 12-month intervention. The newsletters will describe program content and study progress, including

participants' time spent in sedentary behaviours and physical activity and fruit and vegetable consumption from baseline assessments. This information is designed to raise awareness and encourage parents to support their children's physical activity and healthy eating behaviours.

Text messaging has emerged as a potential tool for improving health in youth (Shapiro et al., 2008) and students will be sent weekly (Terms 2/3 and during the school holidays) and bi-weekly (Term 4) text messages encouraging them to be physically active, eat healthily and to reduce sedentary behaviour. The text messages do not require a response from the students and will be both motivational and informational. Messages will be sent at a time appropriate for the specific message. For example, messages to encourage physical activity will be sent in the critical window immediately after school.

The NEAT Girls intervention includes a reward system to encourage study compliance with bronze, silver and gold awards available at each school. Certificates are made available to all participants satisfying the eligibility criteria and in addition, girls who achieve silver and gold awards will enter a draw to win \$30 and \$40 gift certificates, respectively. To be eligible for the bronze certificate, participants must attend at least 80% of enhanced school sport sessions in any one term and complete at least 50% of the home challenges in their physical activity and nutrition handbook or attend at least 50% of lunchtime sessions in any one term. To attain the silver award, participants must attend at least 80% of enhanced school sport sessions for any two terms and at least 50% of lunchtime sessions in any two terms, lead at least one lunchtime physical activity session and complete at least 50% of the home challenges. Finally, to achieve a gold award, participants must attend at least 80% of enhanced school sport sessions for all four terms, complete at least 7/10 of the home challenges, attend at least 70% of lunchtime sessions, and lead at least two lunchtime sessions.

To facilitate the implementation of the NEAT Girls program, cooperating teachers will be invited to attend two one-day workshops at the university. The workshops will be designed to help teachers deliver the intervention components and findings from the baseline assessments will be reported back to the teachers. All intervention schools have been provided with a standard equipment pack (value = \$US1300), which consists of

the following: 15 Gymsticks (elastic tubing resistance training devices), eight sets of boxing gloves, four sets of focus pads, two large skipping ropes, 12 single skipping ropes, iPod docking station, Zumba[®] fitness DVD, Yoga DVD, Pilates DVD, skipping choreography DVD, 15 fit balls, two giant beach balls, pedometers (one for each student), recipe cards and TEMplates[™] (one for each student). The TEMplate[™] is a portion disc that fits on a dinner plate to guide selection of appropriate portion sizes of a variety of vegetables, lean protein sources and healthy carbohydrates. Following the completion of 24-month assessments, the control schools will receive the equipment packs and intervention materials. A condensed version of the NEAT Girls intervention will be offered to the schools at this time.

5.2.7 Outcome Measures

Baseline assessments were conducted by trained RAs at the study schools. A protocol manual was used by RAs, which included specific instructions for conducting all assessments. Physical assessments were conducted in a sensitive manner (e.g., weight was measured away from other students) and questionnaires were completed after the physical assessments in exam-like conditions. The primary outcome measure is BMI; secondary outcome measures are body fat from bioelectrical impedance, muscular fitness, objectively measured physical activity, dietary and sedentary behaviours, social-cognitive measures related to physical activity and dietary behaviours, physical self-perceptions and self-esteem.

Height and weight. Weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1kg. Height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). BMI was calculated using the equation ($\text{weight}[\text{kg}]/\text{height}[\text{m}]^2$) and BMI z-scores were calculated using the ‘LMS’ method (Cole, Bellizzi, Flegal & Dietz, 2000).

Body fat. Percentage body fat, fat mass (FM) and fat-free mass (FFM) were determined using the Imp[™] SFB7 bioelectrical impedance analyser, which is a multi-frequency, tetra polar bioelectrical impedance spectroscopy device (Nielson et al., 2007).

Muscular fitness. A modified version of the 90° push-up test (90PU) was used as a measure of upper body muscular endurance (Cooper Institute for Aerobics Research, 1992). Participants started in the push-up position with their hands and knees touching the floor and the arms at shoulder width apart. Keeping their back straight and hips extended, participants then lowered themselves to the ground until there was a 90-degree angle at the elbows, with upper arms parallel to the floor. A tester held their hand at the point of the 90-degree angle so that the shoulder of the participant touched the observer's hand, then pushed back up. The push-ups were completed in time to a metronome set at 40 beats per minute with one complete push-up every three seconds. The prone support test was used to provide a measure of core abdominal isometric muscular endurance. Participants started lying face down on a gym mat, then propped themselves up on their elbows and toes so that their body was in a straight line (hips and knees are not to be flexed). The participant was timed to see how long they could hold the prone support position before dropping a knee to the ground.

Physical activity. ActiGraph accelerometers (MTI models 7164, GT1M and GT3X) were worn by participants during waking hours for seven consecutive days, except while bathing and swimming. The accelerometers were worn on a small elastic belt and positioned in front of the right hip. Trained RAs, following standardised accelerometer protocols (Trost, McIvor & Pate, 2005) fitted the monitors and explained the monitoring procedures to study participants. To improve compliance with the study protocols, participants were sent text messages each morning during the seven-day monitoring period reminding them to wear the monitors. Data were collected and stored in 30-second epochs and the mean activity counts per minute (CPM) was calculated. Age and gender specific cut-points were used to categorise physical activity into sedentary, light, moderate and vigorous intensity activity (Freedson, Poher & Janz, 2005).

Dietary behaviour. Dietary intake was assessed using the Australian Eating Survey (AES). The AES is a 135-item semi-quantitative FFQ, which was previously tested for reliability and relative validity (Watson, Collins, Sibbritt, Dibley & Garg, 2006). The tool demonstrated acceptable accuracy for ranking nutrient intakes in Australian youth nine to 16 years (Watson, Collins, Sibbritt, Dibley & Garg, 2009) and is currently being validated in adults. Portion sizes for individual food items were accessed from the ABS and unpublished data from the 1995 Australian National Nutrition. Subjects were asked

about frequency of their dietary consumption (by portion size for individual food items) over the previous six months. The frequency options ranged from ‘never’ to ‘four or more times per day’ but varied depending on the food item.

Twenty-one questions relate directly to the intake of vegetables and 11 to fruit, with seasonal availability of some fruits considered in the nutrient analysis. The frequency categories were listed as for other food items, with the question, ‘*When the following fruit is in season, how often do you usually eat it?*’ with seasonal availability determined by data provided by fresh food markets in Sydney, NSW, in addition to referring to supermarket literature that indicated the months of the year different seasonal fruit was available. The AES includes additional questions about the total number of daily serves of fruit, vegetables, bread, dairy products, eggs, fat spreads, sweetened beverages and snack foods, as well as asking the type of bread, dairy products and fat spreads used. Twelve questions relate to food-related behaviours, including items on frequency of take-away food consumption and eating while watching TV.

Sedentary behaviours. The Adolescent Sedentary Activity Questionnaire (ASAQ) was used to provide a self-report measure of time spent in sedentary behaviours (Hardy, Booth & Okely, 2007). The ASAQ requires respondents to report time spent in the following activities: watching TV/videos/DVDs, computers, e-games and e-communication, study, reading, sitting with friends, telephone use, listening or playing music, motorised travel, hobbies and crafts, all performed out of school hours.

Physical activity and dietary social-cognitive mediators. Social-cognitive scales for physical activity (see Table 5.3) and dietary (see Table 5.4) behaviours based on constructs from SCT (Bandura, 2004) were designed for the study. Participants completed separate physical activity and nutrition scales for the following constructs: self-efficacy, social support, environmental perceptions (situation), behavioural strategies (self-control), outcome expectations (perceived benefits), outcome expectancies (value placed on benefits) and intention. The validity and two-week test-retest reliability of the measures was assessed in a sample ($n = 171$) of Australian adolescents (66 = males; 105 = females; mean age = 13.6 ± 1.2 years). Selected subscales (i.e., strength, body fat, appearance, general physical self-concept and global self-esteem) from Marsh’s Physical Self-Description Questionnaire (Marsh, Richards,

Johnson, Roche & Tremayne, 1994) were included as potential outcomes and mediators of physical activity behaviour.

Process evaluation. A detailed process evaluation will be undertaken to assess the feasibility of the NEAT Girls program. This will include: recruitment (achievement of target sample size); retention (retention rates at 12- and 24-month follow-ups); attendance (at enhanced school sport sessions, interactive seminars and lunchtime physical activity sessions); intervention fidelity (24 randomly selected sessions will be observed by a member of the research team and participants will submit their physical activity and nutrition handbooks); and acceptability and program satisfaction (students and teachers will complete detailed process evaluation questionnaires at the completion of the study).

5.2.8 Statistical Methods

Statistical analyses will be conducted using mixed models, which have the advantage of being robust to the biases of missing data and provide appropriate balance of Type 1 and Type 2 errors (Mallinckrodt, Watkin, Molenberghs, Carroll & Lilly, 2004). The models will be specified to adjust for the clustered nature of the data and the analysis conducted using established models (Murray, 1998). The mixed models will be analysed using the PROC MIXED statement in SAS V9.1 (SAS Institute Inc Cary NC). The study was designed to randomise in matched pairs where matching has been shown to improve the power if the number of groups per condition is greater than 10 or the matching correlation is greater than 0.30. As this study has less than 10 groups, the power analysis and analysis plan have conservatively been designed to incorporate the matching if the correlations between the matching variable and the dependent variable (BMI) or the correlation on BMI between members of a pair are high (Diehr, Martin, Koepsell & Cheadle, 1995). Multiple imputation will also be considered as a sensitivity analysis if the dropout rate is substantial. Mediation analysis will be conducted by assessing hypothesised social-cognitive mediators of physical activity and nutrition behaviour change using the PROduct of Confidence Limits for INdirect effects (PRODCLIN) program (MacKinnon, Fritz, Williams & Lockwood, 2007).

Table 5.3: Social-cognitive scales for physical activity behaviour

Variables	Description and example items	Range (No. of items)	ICC (95% CI)	α	χ^2	df	p	GFI	RMSEA
Self-efficacy	Confidence in ability to adopt, maintain and overcome barriers to PA behaviours. For example: <i>'I can still find the time to be physically active even when I've had a busy day'</i> .	1–6 (5)	0.91 (0.88 to 0.93)	0.69	3.82	5	0.58	0.99	0.00
Environmental perceptions	An individual's mental representation of their environment that may influence their PA behaviour:								
	• Home environment—For example: <i>'At home I have access to equipment that helps me to be physically active—e.g., bikes, balls, skateboards'</i> .	1–6 (3)	0.88 (0.83 to 0.91)	0.63	11.22	8	0.19	0.98	0.05
	• School environment—For example: <i>'At school, facilities are available during recess/lunch for me to be physically active—e.g., the gym, dance studio, sports equipment'</i> .	1–6 (3)	0.85 (0.79 to 0.89)	0.65	11.22	8	0.19	0.98	0.05
Social support	Social influences that reinforce PA through encouragement and role modelling:								
	• Peer support— <i>'... how often did you make plans with your friends to be physically active together?'</i>	1–5 (4)	0.91 (0.88 to 0.94)	0.78	27.40	19	0.10	0.97	0.05
	• Family support—For example: <i>'... how often did members of your family participate in physical activities/sports with you?'</i>	1–5 (4)	0.86 (0.81 to 0.90)	0.74	27.40	19	0.10	0.97	0.05
Behavioural strategies	Self-reinforcement for PA achieved through setting goals, monitoring behaviour and self-reward. For example: <i>'... did you organise to be physically active with a friend or family member?'</i>	1–5 (6)	0.91 (0.88 to 0.93)	0.79	15.45	9	0.16	0.97	0.07

Outcome expectations	Anticipated outcomes of PA such as the benefits. For example: ' <i>Participation in regular physical activity can help me to improve my fitness</i> '.	1–6 (5)	0.82 (0.75 to 0.86)	0.75	11.26	5	0.03	0.97	0.09
Outcome expectancies	The value placed on anticipated outcomes of PA. For example: ' <i>How important is improving your fitness to you?</i> '	1–4 (5)	0.88 (0.83 to 0.91)	0.66	15.74	5	0.01	0.97	0.11
Intentions	Intention to be physically active.	1–4 (1)	0.79 (0.72 to 0.85)	NR	NR	NR	NR	NR	NR

Note: α , Cronbach alpha; χ^2 , Chi-square; df , degrees of freedom; GFI, goodness-of-fit index; ICC, Intra-class correlation for 2-week test-retest reliability; NR, not relevant.; p , probability; PA, physical activity; RMSEA, root mean square error of approximation.

Table 5.4: Social-cognitive scales for dietary behaviour

Variables	Description and example items	Range (No. of items)	ICC (95% CI)	α	χ^2	df	p	GFI	RMSEA
Self-efficacy	Confidence in ability to adopt, maintain and overcome barriers to healthy eating behaviours. For example: <i>'I find it easy to choose a healthy snack when I eat between meals—e.g., fruit, reduced-fat yoghurt'</i> .	1–6 (7)	0.89 (0.85 to 0.92)	0.70	17.41	9	0.04	0.97	0.07
Environmental perceptions	An individual's mental representation of their environment that may influence their dietary behaviours. For example: <i>'At home, fruit is always available to eat—e.g., fresh, canned or dried'</i> .	1–6 (4)	0.81 (0.75 to 0.86)	0.79	0.90	2	0.64	1.00	0.00
Social support	Social influences that reinforce healthy eating through encouragement and role modelling. For example: <i>'... how often do your parents prepare a healthy home-cooked dinner for you?'</i>	1–5 (5)	0.89 (0.85 to 0.92)	0.68	10.24	9	0.33	0.98	0.03
Behavioural strategies	Self-reinforcement for healthy eating achieved through setting goals, monitoring behaviour and self-reward. For example: <i>'During meals do you leave food on your plate once you feel full?'</i>	1–5 (6)	0.88 (0.84 to 0.91)	0.75	6.69	9	0.67	0.99	0.00
Outcome expectations	Anticipated outcomes of healthy eating such as the benefits. For example: <i>'Healthy eating can help me to control my weight'</i> .	1–6 (5)	0.84 (0.79 to 0.88)	0.72	14.67	5	0.01	0.97	0.10
Outcome expectancies	The value placed on anticipated outcomes of healthy eating. For example: <i>'How important is controlling your weight to you?'</i>	1–4 (5)	0.89 (0.87 to 0.92)	0.65	4.10	5	0.54	0.99	0.00
Intentions	Intention to eat healthily. For example: <i>'... do you intend to choose reduced-fat foods and drinks whenever you have a choice?'</i>	1–4 (5)	0.83 (0.77 to 0.87)	0.71	9.77	5	0.08	0.98	0.08

Note: α , Cronbach alpha; χ^2 , Chi-square; df , degrees of freedom; GFI, goodness-of-fit index; ICC, Intra-class correlation for 2-week test-retest reliability; p , probability; RMSEA, root mean square error of approximation.

The characteristics of the study participants at baseline are reported in the results section of this paper. Estimates of baseline characteristics for the treatment and control groups were adjusted for clustering by school using PROC MIXED in SAS V 9.1 (SAS Institute Inc, Cary, NC) and ICCs were calculated for key outcomes. Differences between intervention and control groups at baseline were examined using independent samples *t*-tests in PASW Statistics 17 (SPSS Inc. Chicago, IL) software and alpha levels were set at $p < .05$.

5.3 Results

Twelve schools were recruited and 357 participants were assessed at baseline, representing a 99.2% of the targeted sample size (see Table 5.5). Results are provided as means \pm standard deviations, unless otherwise noted. There were no statistically significant differences between control and intervention groups at baseline for any of the demographic or outcome variables. Most participants were born in Australia (97.8%), spoke English at home (98.6%), and identified their cultural background as Australian (85.4%). A high percentage of participants were classified as overweight (26.1%) and obese (16.8%).

The ICC values for BMI, BMI z-score, MVPA minutes, SSR and kilojoules per kilogram per day (kJ/kg/day) were .03, .03, .09, .04 and .03, respectively. Two hundred and 30 participants wore accelerometers for ≥ 600 minutes on at least four days. From this number, only 10.4% met the physical activity recommendations of at least 60 minutes of MVPA each day (averaged across days monitored). A small proportion of participants (11.2%) met the SSR guidelines of less than two hours/day and girls reported consuming 168 (± 87) kilojoules per kilogram per day.

Table 5.5: Baseline characteristics of study sample

Characteristics	Control (<i>n</i> = 179)		Intervention (<i>n</i> = 178)		Total (<i>n</i> = 357)	
	Mean	SD(SE)	Mean	SD(SE)	Mean	SD(SE)
Age (years)	13.2	.4 (0.04)	13.2 (13.2)	.4 (0.04)	13.2	.5 (0.02)
Country of birth, <i>n</i> (%) ¹	174	97.2%	175	98.3%	349	97.8%
Cultural background ²						
Australian, <i>n</i> (%)	153	85.5%	152	85.4%	305	85.4%
Asian, <i>n</i> (%)	1	.6%	3	1.7%	4	1.1%
European, <i>n</i> (%)	18	10.1%	18	10.1%	36	10.1%
Other, <i>n</i> (%)	7	4.0%	4	2.2%	11	3.1%
Weight (kg)	58.4	13.8 (1.44)	58.4	14.2 (1.44)	58.4	13.9 (0.74)
Height (m)	1.61	.07 (0.00)	1.60	.06 (0.01)	1.60	.07 (0.00)
BMI (kg/m ²)	22.6	4.5 (0.48)	22.7	4.7 (0.48)	22.6	4.6 (0.24)
BMI <i>z</i> -score	.78	1.17 (0.12)	.82	1.12 (0.12)	.80	1.14 (0.06)
BMI Category						
Underweight, <i>n</i> (%)	1	.6%	1	.6%	2	.6%
Healthy weight, <i>n</i> (%)	99	55.3%	103	57.9%	202	56.6%
Overweight, <i>n</i> (%)	50	27.9%	43	24.2%	93	26.1%
Obese, <i>n</i> (%)	29	16.2%	31	17.4%	60	16.8%
BIA (body fat %)	28.3	6.8 (1.02)	29.6	6.5 (1.03)	28.9	6.7 (0.35)
Push-up test (reps)	12	8 (1.12)	12	9 (1.12)	12	8 (0.44)
Prone support test (s)	48	34 (5.32)	54	34 (5.33)	51	34 (1.82)
MVPA (mins/day) ³	33.6	16.4 (2.63)	36.9	17.7 (2.63)	35.3	17.1 (1.27)
Meeting MVPA guideline, <i>n</i> (%) ⁴	11	9.6%	13	11.2	24	10.4%
SSR (mins/day)	262.4	170.5 (18.81)	284	162.3 (18.90)	273.2	166.6 (8.83)
Meeting SSR guidelines, <i>n</i> (%) ⁵	23	12.8%	17	9.6%	40	11.2%
Dietary intake (kJ/kg/day)	163.4	81.3 (8.69)	173.0	91.4(8.71)	168.2	86.5(4.58)

Note: BIA, Bioelectrical impedance analysis; BMI, Body mass index; mins, Minutes; MVPA, Moderate-to-vigorous physical activity; s, Seconds SD, Standard deviation; SE, Standard error; SSR, Small-screen recreation. ¹Participants born in Australia; ²One participant did not report their cultural background; ³*n* = 114 (Control) and *n* = 116 (Intervention) for participants who wore accelerometers for ≥600 minutes on ≥4 days; ⁴Participants meeting the MVPA of ≥60 minutes of MVPA; ⁵Participants not exceeding the SSR recommendations of ≥120 minutes each day.

5.4 Discussion

To the authors' knowledge, this is the first school-based obesity prevention program for Australian adolescent girls from disadvantaged secondary schools. Targeting low-active girls from such schools is important because physical activity (Story et al., 2002) and fruit and vegetable consumption is lower in this group compared to those from mid- and high-SES strata (Booth et al., 2006). Consequently, the prevalence of overweight and obesity is significantly higher among adolescents from low-SES backgrounds (Dollman & Pilgrim, 2005; Miech et al., 2006; Stamatakis et al., 2010).

We successfully recruited 12 secondary schools and 357 adolescent girls. The target sample size was achieved in less than six weeks, suggesting that the proposed program was appealing to the target group. The challenge of recruiting adolescents has been noted in the literature and this difficulty may prevent many studies from being conducted and published (Steinbeck et al., 2009). PE teachers at the study schools were responsible for the identification and recruitment of low-active girls. Girls were eligible if they were considered by their teachers to be disengaged in PE and/or not currently participating in organised team or individual sports within or outside of school.

Of those participants who wore accelerometers for ≥ 600 minutes on at least four days, only 10% met the physical activity recommendations of at least 60 minutes of MVPA each day. Based on a representative sample of US adolescents who had worn accelerometers for at least one day, Troiano and colleagues (2008) reported that only 3.4% of girls aged 12–15 years attained sufficient physical activity to meet public health recommendations. While the percentage of adolescent girls achieving the MVPA guidelines was higher in our study, our prevalence estimates were based on those who wore accelerometers for at least four days. It has been suggested that four days of objective monitoring of physical activity is required to provide an accurate assessment of habitual activity (Trost, Pate, Freedson, Sallis & Taylor, 2000) and estimates based on only one day of monitoring may be less precise than those based on multiple days. In the current study, participants were sent text messages every morning to remind them to wear their accelerometers. This strategy contributed to a high level of compliance

among participants, but a number of accelerometers malfunctioned, resulting in unusable data for 50 participants.

Almost forty-three per cent of the study sample were overweight (26.1%) or obese (16.8%). This represents almost double the prevalence of overweight and obesity (23%) found in the Australian National Children's Nutrition and Physical Activity Survey (Department of Health and Ageing, 2008). The high prevalence of overweight and obesity found in the study sample is consistent with previous studies that have identified a higher prevalence of obesity in adolescents from low-SES groups (Dollman & Pilgrim, 2005; Miech et al., 2006; Stamatakis et al., 2010). An advantage of our recruitment strategy is that we were able to identify and attract adolescent girls to a targeted school-based program without stigmatisation and our process measures will determine whether girls' participation in the study was a positive experience.

Preventing unhealthy weight gain among adolescent girls is difficult, and many school-based interventions, both targeted (Neumark-Sztainer et al., 2003; Robbins et al., 2006; Schneider-Jammer et al., 2004; Schofield, Mummery & Schofield, 2005) and whole-of-school (Pate et al., 2005; Sallis et al., 2003), have been unsuccessful. One possible reason for the failure of previous approaches is that they have failed to impact upon family support for physical activity and healthy eating. In a two-year study with Belgian adolescents, Haerens and colleagues (2006) found that their intervention with parental support was successful in preventing unhealthy weight gain in girls. Engaging parents in health promotion programs is difficult (Perry et al., 1988), but their influence on physical activity and dietary behaviours is pervasive and therefore strategies to involve parents are warranted (Golley et al., 2011). The NEAT Girls intervention includes a number of innovative strategies designed to encourage parents to support their daughters' physical activity and dietary behaviours which are communicated in the newsletters sent to parents.

The NEAT Girls intervention has the potential to be a successful and sustainable approach to obesity prevention in adolescent girls from disadvantaged schools. It has a strong theoretical foundation (Bandura, 1986) and the intervention strategies were designed to target specific mediators of physical activity and nutrition behaviour change. To improve our understanding of behaviour change, hypothesised mediators

will be tested in a mediating variable framework (Baranowski, Cerin & Baranowski, 2009; Baranowski, Klesges, Cullen & Himes, 2004). To help reduce the decline in physical activity associated with adolescence (Nader et al., 2008), participants will be provided with a range recreational lifetime physical activities that can be easily completed within and beyond the school setting. Further, the majority of the intervention will take place during timetabled school sport and the lunchtime physical activities will be delivered by study participants, both of which will contribute to the sustainability of the program.

In terms of study adherence, participants will be provided with pedometers for self-monitoring and encouraged to increase their incidental physical activity. Adherence is inversely related to exercise intensity and interventions promoting moderate-intensity lifestyle activity have been found to have good adherence (Lubans, Morgan, Callister et al., 2009; Perri et al., 2002). NEAT Girls includes a number of components designed to support physical activity and dietary behaviour change, including rewards, text messaging, nutrition workshops and strategies to engage parents to support the physical activity and dietary behaviours of their children. These methods will help to increase motivation and reduce the deterioration in physical activity and dietary behaviours associated with adolescence.

5.5 Conclusion

NEAT Girls is an innovative intervention targeting low-active girls using evidence-based behaviour change strategies and has the potential to prevent unhealthy weight gain by improving physical activity and dietary behaviours. Few studies have reported the effects of mediation analyses from youth interventions to promote physical activity and healthy eating (Cerin et al., 2009; Lubans et al., 2008) and this study will provide insights into the mechanisms of behaviour change to assist in the design of future obesity prevention trials. These insights will build on the existing knowledge and help to guide interventions targeted towards ‘at-risk’ groups.

Chapter 6: A Longitudinal Test of the Social Cognitive Theory to Explain Change in Physical Activity Behaviour in Adolescent Girls of Low-SEP

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Major Findings

This paper reports the findings of a longitudinal test of SCT to explain change in physical activity behaviour (MVPA minutes/day) over a 12-month period among adolescent girls of low-SEP. The model tested explained 28% and 34% of variance in physical activity behaviour change and intention respectively. Model-fit indices indicated the data were a good fit to the model. However, self-efficacy was the only cognition to directly predict behaviour change. Hence, the proposed pathways in the SCT model were not well supported.

6.1 Introduction

Despite the extensive health benefits and protective effects of engaging in regular physical activity (Warburton, Nicol & Bredin, 2007), participation levels among many adolescents remain inadequate with a large proportion failing to achieve the recommended 60 minutes of daily MVPA (US Department of Health & Human Services, 2008). Further, physical activity participation rates decline during adolescence, and there is evidence to suggest that this decline is more pronounced in females and among those of low-SEP (Brodersen, Steptoe, Boniface & Wardle, 2007; Nader et al., 2008). Consequently, establishing successful interventions that improve physical activity behaviour in high-priority adolescent groups is needed, and an important part of this process is improving our understanding of what drives physical activity behaviours in these groups. As such, researchers have been prompted to adopt models of social cognition to help identify what role various psychological and social factors may have in influencing physical activity behaviour in young people (Hagger, 2009).

Social-cognitive theories (e.g., SCT, TPB, HPM) typically propose a framework or model that specifies relationships among psychological and social factors within a scheme that is hypothesised to determine a health behaviour. Testing theoretical models extends our understanding of health behaviour by examining how proposed factors may interrelate to predict or explain patterns of behaviour. This research is important because the findings can help to support or refute a theory's utility in guiding effective theoretically based interventions.

Prominent among models of social cognition is Bandura's (1986) SCT, which provides a framework for explaining why people acquire and maintain healthful behaviours. According to Bandura (1986), human behaviour is the product of the dynamic interplay of personal, environmental and behavioural factors. This relationship between factors is referred to as 'reciprocal determinism', as each factor may affect or be affected by the others. In Bandura's (2004) more recent commentary of SCT, a framework is presented that specifies a core set of determinants and the mechanisms through which these determinants are operationalised to influence health-promoting behaviour. These

determinants include knowledge, self-efficacy, goals, outcome expectations, and perceived facilitators and impediments. What creates the precondition for behaviour change is *knowledge* of the health risks and benefits of a particular health-related habit, but additional self-influences are often needed to help people overcome possible inertia to change.

Self-efficacy is considered the central determinant in SCT because it influences behaviour both directly and indirectly through goals, outcome expectations and facilitators/impediments. Self-efficacy refers to an individual's belief in their capacity to exercise control over their behaviour (e.g., I can still find the time to be physically active even when I've had a busy day). Personal belief is paramount in personal change because it provides motivation and incentive to overcome barriers to change, and evokes feelings of empowerment to enact change.

In SCT, *goals* are hypothesised to be the direct antecedent to behaviour and are equivalent to the construct 'intentions' in the TPB (Ajzen, 1991). Bandura (2004) explains that intentions can be considered proximal goals since *aiming* to perform a particular behaviour (e.g., to participate in physical activity on most days of the week) is essentially the same as *intending* to perform a particular behaviour. Goals, when highly valued, enhance motivation to adopt healthy behaviour practices. While goals can be proximal or distal, short-term goals are most effective in enacting behaviour change.

Outcome expectations are hypothesised to directly predict behaviour and one's goals. Outcome expectations refer to the outcomes people expect their actions to produce, which can be physical, social and self-evaluative in nature. In the physical activity context, physical outcomes can encompass the pleasant and negative effects of being physically active and the related losses and gains. Social outcomes involve interpersonal relationships and how significant others may reinforce or discourage future displays of a behaviour. Behaviour is also regulated by self-evaluative reactions. That is, people continue to behave in ways that give them self-satisfaction and self-worth, and abstain from behaviours that induce feelings of self-dissatisfaction.

Finally, *facilitators* and *impediments* to health behaviour encompass the perceived social factors (e.g., family/peer support reinforcing physical activity) and structural

factors (e.g., access to facilities to support physical activity) that may encourage or obstruct healthy practices. In the SCT model, facilitators and impediments are hypothesised to determine one's goals in striving for a health behaviour.

In summary, the relationships between the SCT determinants are operationalised such that individuals with high efficacy beliefs tend to expect more favourable outcomes for their efforts, are more likely to overcome barriers to performing the behaviour, and demonstrate stronger commitment to the goals they set themselves. In comparison, individuals with poor efficacy beliefs expect their efforts to result in poor outcomes, and perceive barriers to behaviour to be insurmountable and the necessary support to facilitate behaviour change to be largely absent, leading to less likelihood of planning for and enacting a behaviour.

There is an extensive literature reporting a range of social-cognitive influences of physical activity behaviour in children and adolescents. For example, there is consistent support for self-efficacy, enjoyment, barriers, family and peer support to be positively associated with physical activity levels in adolescent girls (Biddle et al., 2005). There is also evidence to indicate the mediating role of self-efficacy, perceived barriers, perceived benefits and enjoyment of intervention effects on physical activity behaviour (Lubans et al., 2008). Yet, research investigating the explanatory power of social-cognitive models for adolescent physical activity behaviour is limited (Plotnikoff et al., 2013). In their recent review and meta-analysis, Plotnikoff and colleagues (2013) revealed the TPB was the most commonly tested model in adolescents, but that most of the variance in physical activity remains unexplained. The authors found that three studies had evaluated models based on SCT and that no studies had tested the utility of Bandura's (2004) reconceptualised model for explaining physical activity in adolescents.

Ramirez and colleagues (2012) examined an abridged version of Bandura's (2004) model to explain physical activity in children using an objective measure of behaviour (step counts by pedometers). Yet, the model was not well supported. Only 2% of the variance in physical activity was explained and goals emerged as the only direct determinant of behaviour. In a recent cross-sectional study, Martin et al. (2011) examined the capacity of several SCT constructs to directly predict self-reported

physical activity in a sample of middle school students. Only a small proportion of the variance in physical activity was accounted for by the model (12%), and only barriers self-efficacy and classmate social support were found to predict physical activity. In comparison, Taymoori et al. (2010) found stronger support for their SCT model when tested with adolescent girls, which explained 52% of the variance in physical activity. In their model, direct effects from barriers self-efficacy and outcome expectations, and indirect effects from parental and peer social support through self-efficacy on physical activity were reported.

Identifying appropriate health behaviour theories is essential for improving our understanding of behaviour change and designing effective interventions. Indeed, there is good evidence to show that interventions guided by theory are more likely to produce stronger effects than interventions developed without theory (Ammerman et al., 2002). However, the existing evidence base for children and adolescents is limited (Plotnikoff et al., 2013). In their recent review of adolescent studies, Plotnikoff and colleagues (2013) identified an over-reliance on cross-sectional designs, and the need for more rigorous and applied theory tests using longitudinal and experimental studies. The authors also expressed concern for the almost exclusive use of self-report measures of physical activity for tests of theory as only two studies had used objective measures of physical activity. Self-report measures have been criticised for their questionable accuracy due to response bias and the difficulty that young people have recalling their behaviour (Sallis & Saelens, 2000).

As such, the aim of this study was to test the proposed structural paths of Bandura's (2004) SCT model to explain changes in objectively measured physical activity over a 12-month period in a sample of adolescent girls. To the authors' knowledge, this is the first study in adolescents to test the explanatory power of Bandura's (2004) SCT model in an analysis of physical activity change.

6.2 Methods

6.2.1 Study Design

Data from the NEAT Girls group RCT (Lubans, Morgan, Dewar et al., 2010; Lubans et al., 2012) were examined and reported in the present study. NEAT Girls is a 12-month multi-component school-based obesity prevention intervention, which targeted adolescent girls from schools in low-income communities. Ethics approval for NEAT Girls was obtained from the University of Newcastle, Australia and the NSW Department of Education and Training Human Research Ethics Committees. School Principals, study participants and their parents provided written informed consent to participate in the program, which commenced in July 2010.

6.2.2 Participants

The SEIFA index of relative socio-economic disadvantage (scale 1 = lowest to 10 = highest) was used to identify eligible secondary schools from low-income communities, which establishes summary characteristics of people and households within a school's locality (employment, education, financial wellbeing, housing stress, overcrowding, home ownership, family support, family breakdown, family type, lack of wealth, low-income, Indigenous status and foreign birth) (ABS, 2001). Eligible schools were government secondary schools with a SEIFA index of ≤ 5 (lower 50%) from the Hunter and Central Coast regions of NSW. Twelve schools were recruited, from which 357 adolescent females consented to participate (i.e., approximately 30 participants per school). PE teachers at the participating schools identified and recruited students who were at risk for physical inactivity. That is, eligible students included those who were often disengaged and resisted participation during PE, and reported no current involvement in organised team or individual sports within or outside of school.

6.2.3 Model Tested

For the current study, baseline cognitions were hypothesised to predict physical activity behaviour *change* over a 12-month period (see Figure 6.1). That is, self-efficacy, outcome expectations and proximal goals would directly predict change in MVPA

(daily minutes), and that outcome expectations, proximal goals, and facilitators would mediate the relationship between self-efficacy and MVPA change. How the social-cognitive variables were targeted in the NEAT Girls intervention is explained previously in detail (Lubans, Morgan, Dewar et al., 2010). Since *barriers self-efficacy* was specifically examined, impediments were not included as proposed in Bandura's (2004) model. According to Bandura (2004), intentions can be considered proximal goals to perform a behaviour, hence proximal goals have been included in the model as a measure of intention. Finally, parental support was used to represent facilitators of physical activity in the model. This is based on the most consistent evidence for parental support to be an important correlate and determinant of physical activity in adolescent girls specifically (Biddle et al., 2005; Peterson, Lawman, Wilson, Fairchild & Lee Van Horn, 2013). While there is some evidence for peer support to be associated with adolescent physical activity (e.g., Ferreira et al., 2007), other research has deemed this relationship to be indeterminate (Sallis et al., 2000). Moreover, the parental support measure included in the models assessed multiple dimensions of social support, including mutual participation in physical activity (i.e., parent and child together), provision of equipment and opportunities to support participation in physical activity by the parent, and general encouragement from the parent.

6.2.4 Outcome Measures

Data were collected in May/June of 2010 (T1) and 2011 (T2) at the study schools by trained RAs. The social-cognitive measures were completed by study participants at T1 in exam-like conditions. Accelerometers were distributed on the same day, and were to be worn by participants for the following seven days. The procedure for accelerometers was repeated again at T2.

Height and weight. Participant's weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) to the nearest 0.1kg. Height was recorded to the nearest 0.1 cm using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). From this, BMI was calculated [$\text{weight(kg)}/\text{height(m)}^2$] and BMI z-scores were also derived to determine weight status.

Physical activity. ActiGraph accelerometers (MTI models GT1M and GT3X; ActiGraph, LLC, Fort Walton Beach, FL) were used to collect physical activity data at baseline and 12 months. Comparisons of the output generated by the various ActiGraph accelerometers used in this study suggests that the data are comparable for estimating physical activity (John, Tjo & Bassett, 2010). Participants were asked to wear the devices for seven consecutive days, except while bathing and swimming. Uniaxial data were collected and stored in 30-second epochs and age specific cut-points were used to categorise physical activity into moderate (1148–2005 counts) and vigorous (≥ 2006 counts) intensity activity (Trost, Loprinzi, Moore & Pfeiffer, 2011). Non-wear time was determined by strings of consecutive 0 counts ≥ 20 minutes, allowing an interruption interval of one minute of counts between 0 and 100. Data were only included in the analyses for cases where wear time ≥ 600 minutes per day for at least three days.

Social-cognitive scales for physical activity. Four social-cognitive scales related to adolescent physical activity behaviour were used: self-efficacy, intention, parental support and outcome expectations related to physical activity (Dewar, Lubans, Plotnikoff & Morgan, 2013). The scales are based on constructs from the SCT and were previously tested in a separate adolescent sample ($n = 171$, mean age 13.6 ± 1.2 years). Reliability (two-week test-retest) and internal consistency for each scale are identified below. The introduction to each scale included a referent that asked respondents to specifically consider participation in regular MVPA when responding to each item. Regular MVPA was defined as '*participating in a total of 60 minutes of at least moderate-intensity activity on all or most days of the week*', and suitable examples were provided. This referent was important to ensure that the cognitions for behaviour were matched with the physical activity outcome (i.e., MVPA) used in the analyses.

The five-item self-efficacy measure primarily measured barriers-efficacy, which was operationalised as an individual's belief in their ability to overcome barriers to participation in MVPA ($ICC = .91$, $\alpha = .69$). For example, '*I find it difficult to be physically active when I've had a busy day*'. Each item was measured on a six-point Likert-type scale of 1 (*strongly disagree* indicating very low efficacy beliefs) to 6 (*strongly agree* indicating very strong efficacy beliefs). Negatively worded items were reverse coded. For each individual, a composite self-efficacy score was obtained by calculating an average (score out of six) from the five efficacy items.

Intention was operationalised as an individual's intention to participate in MVPA on most days of the week over the next *three months*. Intention was examined with a single item using a four-point Likert-type scale of 1 (*not at all true of me* indicating no intention) to 4 (*very true of me* indicating strong intention).

Parental support for MVPA was examined as a facilitator of physical activity as per the facilitators/impediments determinant in Bandura's proposed model. On a five-point Likert-type scale of 1 (*never* indicating no parental support received) to 5 (*always* indicating very frequent parental support received), four items ($ICC = .86$, $\alpha = .74$) assessed a variety of supportive behaviours received from parents to participate in MVPA. For example, '*... did your parents buy you equipment that encouraged you to be physically active (e.g., sports clothes, joggers, a bike, an iPod for listening to music while being physically active?)*'. A composite parental support score was obtained by calculating an average score (out of five) for the four parental support items.

The outcome expectations measure examined the anticipated physical (e.g., '*participation in regular physical activity can help me to control my weight better*') and social (e.g., '*participation in regular physical activity with friends can be fun*') benefits of participating in regular physical activity. Five items were rated on a six-point Likert-type scale of 1 (*strongly disagree* indicating no benefit expected) to 6 (*strongly agree* indicating very positive benefits expected) ($ICC = .82$ and $\alpha = .75$). A composite outcome expectations score was obtained by calculating an average score (out of six) from the five expectation items.

6.2.5 Analysis

SPSS 19.0 software (IBM, SPCC inc. Chicago, IL) was used to calculate the univariate normality, means, and standard deviations for each variable, and the bivariate correlations between the social-cognitive and physical activity variables. Data were transformed using the base 10 logarithmic function to improve normality where necessary. ICCs were calculated to determine the total variability in physical activity that could be explained at the school level. As the ICC values were low (i.e., 4%), the analyses were not adjusted for school. Maximum likelihood analysis (MLE) in AMOS

19.0 (Small Waters Corp. Chicago, IL) was used to examine structural equation modelling (SEM). SEM is an appropriate method for testing health behaviour theories as it allows researchers to test multiple pathways simultaneously and can include variance estimates for more than one dependent variable (Bollen & Long, 1993). The longitudinal model included baseline social-cognitive constructs predicting MVPA change from baseline to 12 months. For parsimony and given sample size ($n = 235$), the model included single indicator latent variables that accounted for measurement error and minimise model parameters.

As the preferred criteria for model evaluation, Hu and Bentler (1999) recommend a two-index presentation strategy. This includes using the MLE-based standardised root mean squared residual (SRMR) because this is the most sensitive index to models with latent structure(s), and supplementing the SRMR with an incremental fit index (i.e., either the CFI, Tucker-Lewis index [TLI], Relative Non-centrality Index [RNI], Bollen's Fit Index [BL89], McDonald's Centrality Index [Mc] or the RMSEA), which are the most sensitive indexes to models with mis-specified factor loadings (Hu & Bentler, 1999). It has been found that a presentation strategy including SRMR and RNI or CFI resulted in the least sum of Type I and Type II error rates and thus may be a preferred combination. Hence, SRMR and CFI are currently reported. In sample sizes smaller than 250, when using combinational rules of SRMR and CFI, acceptable fit indices recommend values < 0.09 and > 0.95 respectively (Hu & Bentler, 1999).

6.3 Results

6.3.1 Descriptive and Bivariate Correlations

For the current analyses, the sample included 235 adolescent girls from 12 secondary schools located in low-income communities. This sample size is based the number of participants with eligible accelerometer data at baseline (i.e., ≥ 600 minutes wear time per day for at least three days). Demographic information at baseline revealed participants ($M = 13.2$ years, $SD = 0.4$) to be predominantly Australian born (97.0%), to speak English at home (98.7%) and to acknowledge their cultural background as Australian (86.9%). The percentage of participants classified as overweight and obese were 24.6% and 14.4%, respectively. There was a slight decline in daily MVPA from

baseline (T1, 39.6 minutes) to 12-months (T2, 34.4 minutes), although this was not statistically significant. Descriptive statistics and bivariate correlations between social-cognitive variables (T1) and MVPA (T1 and T2) are presented in Table 6.1. In summary, bivariate correlations showed significant associations between all social-cognitive variables ($r = 0.25$ to 0.48 , $p < .01$). However, none of the social-cognitive variables was associated with physical activity at T1 or T2.

6.3.2 Structural Model Findings

In the model predicting objectively measured MVPA change over 12-months, 28% and 34% of the variance in behaviour and intention respectively was explained (see Figure 6.1). Fit statistics indicated the data fit the specified model ($\chi^2 = 11.36$, $df = 6$, $p = .08$, CFI = .97, SRMR = 0.06) and standardised path estimates ranged from -0.18 to 0.67 (see Figure 6.1). Between the social-cognitive determinants, three of the five proposed pathways were statistically significant [from self-efficacy to parental support ($\beta = .67$, $p < .001$) and outcome expectations ($\beta = .42$, $p < .001$), and from outcome expectations to intention ($\beta = .54$, $p < .001$)]. The proposed relationships to intention from both self-efficacy and facilitators/impediments to intention were not supported. For the social-cognitive variables directly predicting MVPA change, only self-efficacy was found to be significant predictor ($\beta = .26$, $p < .05$).

Table 6.1: Descriptive statistics and bivariate correlations between baseline social-cognitive variables and physical activity

Variable	Descriptives ^a		Bivariate correlations ^b				
	M	SD	1	2	3	4	5
1. Baseline MVPA (<i>daily mins</i>)	39.61	18.22	–				
2. 12-month MVPA (<i>daily mins</i>)	34.41	16.43	.45**	–			
3. Self-efficacy	3.88	.94	.09	.17*	–		
4. Intention	3.25	.71	.04	–.10	.25**	–	
5. Parental support	3.42	.93	–.01	.08	.45**	.27**	–
6. Outcome expectations	4.18	.50	–.01	–.07	.25**	.48**	.32**

Note: MVPA, moderate-to-vigorous physical activity; ^aUnadjusted means and standard deviations reported; ^bBivariate correlations between adjusted values reported; * $p < 0.10$, ** $p < 0.01$.

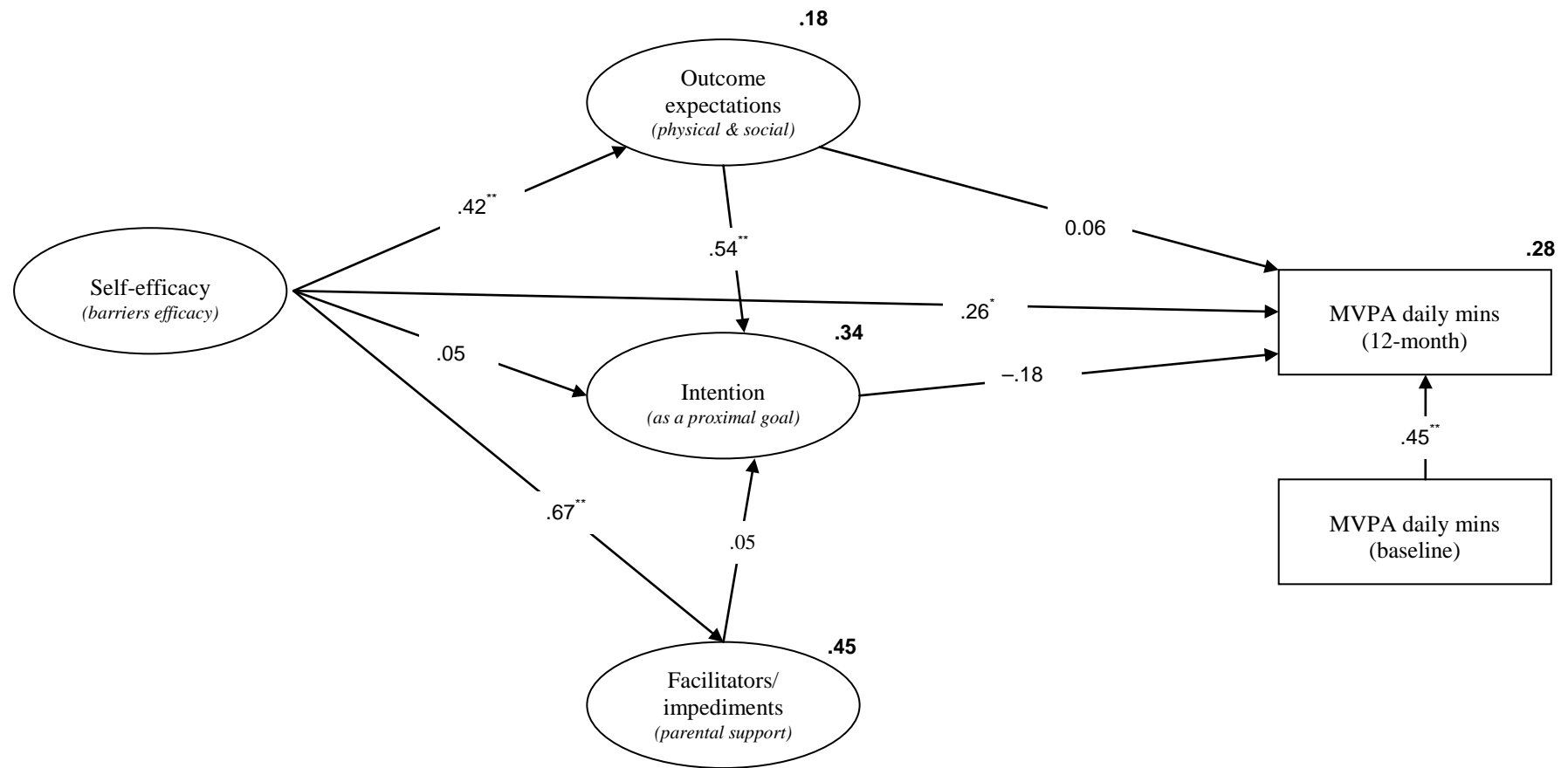


Figure 6.1: Structural pathways between baseline social-cognitive variables and 12-month change in objectively measured MVPA

Note: Path coefficients and squared multiple correlation values are reported for self-reported time spent in moderate-to-vigorous physical activity; **significant pathways at * $p < .05$, ** $p < .001$; values in bold represent r^2 values. To improve the readability of the figure, the indicators of the latent constructs and error terms are not shown.

6.4 Discussion

The aim of this study was to test the hypothesised structural paths of influence in Bandura's (2004) SCT model to explain change in physical activity over a 12-month period in a sample of adolescent girls of low-SEP. To the authors' knowledge, this is the first study to examine the predictive power of SCT to explain physical activity change in this group, which may have important implications for future research guided by evidence-based theory. The results demonstrate that the SCT constructs explained only 28% of the variance in behaviour change, and 34% of the variance in intention. While self-efficacy was found to directly predict change in physical activity in the hypothesised model, intention and outcome expectations did not. Together, these findings suggest the model may require further development when attempting to accurately explain the antecedents of behaviour change in this particular group.

Although the proposed model provided a good fit to the data, the majority of the variance in physical activity and intention remains unexplained. Most of the variance explained in our model is probably due to adjustment for past behaviour. Further, common method artefact may explain the weak bivariate correlations between the social-cognitive variables and objectively measured behaviour. These findings are consistent with a recent meta-analysis of the predictive power of key social-cognitive theories among adolescents, which showed the variance explained for physical activity (33%) and intention (48%) was moderate (Plotnikoff et al., 2013). As such, it may be necessary for future research to revise and/or integrate current theory in order to advance our understanding of physical activity in the adolescent population.

Rhodes and Nigg (2011) discuss testing augmentation of theoretical models with additional physical activity constructs. This procedure can offer rigour to the original model if the additional constructs fail to improve the explained variance of the behaviour. For example, in a recent test of the SCT model in adolescent girls, Lubans and colleagues (2011) added the construct physical self-worth to the model that was hypothesised to directly and indirectly predict objectively measured physical activity through physical activity behavioural strategies and outcome expectations. The rationale for including this construct in the model was based on findings from earlier research

that has shown self-worth to be a predictor of physical activity and an outcome of exercise in adolescent girls (Crocker, Sabiston, Kowalski, McDonough & Kowalski, 2006). Their findings showed physical self-worth was associated with physical activity; however, only 5% of the variance in behaviour was explained suggesting the model was not well supported.

Augmentation can also support integration of theoretical models, by combining constructs that have shown promise for explaining physical activity from across two or more theories to develop unique models of behaviour. For example, Hagger and Chatzisarantis (2009) demonstrated the potential utility of hybrid theory by performing a meta-analysis of studies integrating the TPB and SDT in a variety of health contexts. The findings showed support for a sequence of self-determined motivation from SDT to predict the antecedents of intentions and behaviour from the TPB. Further, pooled results accounted for a larger variance in intention (65%) and behaviour (58%) when compared to the explanatory power of single theoretical models in Plotnikoff et al. (2013) more recent meta-analysis (48% and 33% respectively).

There may also be considerable value in exploring combined models of social cognition with other ecological components such as community, organisation and policy factors (Hagger, 2009; Plotnikoff et al., 2013). The case for this approach is strengthened when we consider the preoccupation with intrapersonal level constructs that models of social cognition are limited by, yet there is good evidence to support environmental influences of physical activity behaviour in youth including policy and community setting influences (e.g., Ferreira et al., 2007).

Besides poor variance explained, the current results demonstrate difficulty in linking the social-cognitive variables to behaviour. Self-efficacy was the only cognition to directly predict behaviour change. The support for self-efficacy is consistent with previous studies that have demonstrated the importance of efficacy beliefs in explaining adolescents' physical activity behaviours (Lubans et al., 2008; Plotnikoff et al., 2013). For example, in cross-sectional and longitudinal tests of the SCT and HPM, self-efficacy has emerged as a consistent predictor of physical activity among various adolescent groups (Martin et al., 2011; Taymoori, Rhodes et al., 2010). Meanwhile, there is also good support for self-efficacy in its role to mediate intervention effects on

physical activity behaviour change among children and adolescents (Taymoori & Lubans, 2008). While the current study examined barriers self-efficacy specifically, Beets et al. (2007) similarly reported strong support for the relationship between barriers self-efficacy and physical activity in adolescent girls. Together, these findings demonstrate that strategies to increase adolescents' self-efficacy for physical activity are justified and should be addressed when attempting to improve physical activity behaviour in this group.

The current study did not support the predictive capacity of intention, as the pathway to behaviour was not significant. The study sample indicated strong intention to be physically active at baseline and it is possible that anticipation of participating in a physical activity intervention had an acute positive effect on their intention to be physically active. Conversely, research reporting intention-behaviour discordance in the physical activity domain is not new. During their recent meta-analysis of experimental evidence, Rhodes and Dickau (2012) demonstrated the intention-behaviour association to be very weak and not meaningful, and suggested that prior evidence to support this association was probably biased by the limits of correlation coefficients in passive research designs.

Closing the intention-physical activity gap has been addressed in the literature, and may start with better measurement of the intention construct. For the current study, intention was examined using a single item. Although this is common practice (Rhodes & Dickau, 2013), it has been suggested that rudimentary measurement using a single item may not be sufficient to assess the concept as originally defined (Ajzen, 1991). Research has also attempted to identify constructs that may bridge the gap between intention and behaviour through theory augmentation. For example, models that focus on mediators of the intention have emerged, suggesting intention may not be the direct antecedent of physical activity as originally theorised, but a more distal determinant in a longer causal chain (e.g., Sniehotta, 2009). For instance, self-efficacy and strategic planning have emerged as post-intentional factors that lead to actual behaviour. Moderating mechanisms have also been explored to help understand intention-behaviour discordance. For example, in their recent review Rhodes and Dickau (2013) found intention stability to be the most consistent moderator of the intention-physical activity gap, whereby higher stability represented a larger intention-physical activity

coefficient. The authors found anticipated regret, conscientiousness, self-efficacy, planning, extraversion, habit and environmental proximity to recreation also showed evidence for moderation. While moderators do not challenge intention as a proximal influence on physical activity behaviour, evidence for moderating mechanisms can help identify factors that impede or facilitate the translation of intentions into behaviour. Hence, it has been suggested that augmented models that focus on action control (i.e., translating an intention into behaviour) may be more practical for explaining physical activity than models that assume intention is the proximal influence on behaviour that is adequate to produce a repeated behavioural act (Rhodes & Dickau, 2012).

Similarly, positive outcomes expected by the study sample did not translate to behaviour. Hence, exploring if additional constructs impact the relationship between expected outcomes and physical activity behaviour in this group may also be warranted. For example, following an online physical activity and dietary intervention, Anderson-Bill and colleagues (2011) found outcome expectations had an indirect positive effect on physical activity through modification of self-regulatory behaviours. Another possibility is exploring expectancy value (i.e., outcome expectancies) as a dichotomous moderating mechanism (i.e., high versus low) between outcome expectations and physical activity. Outcome expectancies are concerned with personal value placed on the perceived benefits of a health behaviour (e.g., improving my physical fitness through physical activity is important to me/is not important to me). It is possible that adolescents recognise the many benefits associated with physical activity, yet if personal value is not placed on these benefits then this knowledge may not directly translate well to positive behaviour change.

In the SCT model, self-efficacy, outcome expectations and parental support were hypothesised to be proximal determinants of intention, however only the pathway between outcome expectations and intention was supported. Failure to detect a significant relationship between self-efficacy and intention could be due to limited measurement of efficacy beliefs. For the current study, barriers self-efficacy was examined, and it may be necessary to additionally examine other forms of self-efficacy (e.g., task-efficacy or any of the different components of regulatory-efficacy) to more accurately determine the strength of the efficacy-intention relationship. Further, the absence of a significant relationship between parental support and intention could be

because we did not additionally examine impediments to physical activity behaviour in the models, and our measure of parental support provided a limited assessment of potential facilitators of participation in physical activity. For example, peer/sibling support, or physical environmental influences are also important influences to explore. Even so, future model testing may be encouraged to examine parental support as a direct influence on physical activity in this group. In other research, parental support has emerged as an important correlate and direct determinant of physical activity in adolescent girls (Biddle et al., 2005; Peterson et al., 2013).

In comparing the current findings with other research in adolescent girls, support for the SCT is weaker than previously reported. For example, a slightly alternative SCT model tested by Taymoori and colleagues (2010) accounted for a larger variance in physical activity (52%), and supported self-efficacy as a direct and indirect (through outcome expectations) influence on physical activity behaviour. Further, our model did not support the role of social support to predict behaviour through intention. Yet, the model tested by Taymoori et al. (2010) suggests social support (parental and peer) may rather influence physical activity when treated as an antecedent of self-efficacy. Comparing findings between studies however should be made with caution. The current study used a longitudinal design to test theory in an analysis of behaviour change while using an objective measure of physical activity. Meanwhile, Taymoori and colleagues (2010) performed a cross-sectional analysis using a self-report measure of physical activity, and it is possible that study design and common method artefact regarding measurement of variables may have biased their results. Even so, there is very little research testing the utility of social-cognitive theories in adolescent girls, and clearly continued efforts with strong study designs are needed to achieve more conclusive evidence in this group.

There are several strengths of this study that should be noted. To the authors' knowledge, this is the first study to test the utility of SCT to predict physical activity behaviour change in adolescent girls over a 12-month study period using an objective measure of behaviour. Further, the study sample represented an underserved adolescent population who have been identified as requiring priority attention (Brodersen et al. 2007; Nader et al., 2008). However, there are also some limitations. The original intervention sample included 357 girls, yet due to attrition of usable accelerometer data, the sample used in the current study included 235 girls. Hence, the findings are not

representative of the complete intervention sample. Intention was examined using a single item measure, and it is important to note that the self-efficacy measure included items that pertained only to barriers-efficacy, hence why impediments to physical activity (as proposed in Bandura's 2004 model) were not examined. Finally, due to the sample size limiting model parameters, parental support was the only factor included as a facilitator to physical activity.

6.5 Conclusion

Acceptable model-fit indices did support the SCT model in this study. However, only a small proportion of the variance in objectively measured physical activity was explained. While the majority of previous research in this area has been cross-sectional, our longitudinal analysis showed the SCT cognitions poorly predicted change in physical activity. Specifically, only the direct effect of self-efficacy on physical activity behaviour change was supported.

Chapter 7: One-year Outcomes of the NEAT Girls Obesity Prevention Intervention: Part One

Lubans, D. R., Morgan, P. J., Okely, A. D., Dewar, D. L., Collins, C. E., Batterham, M., Callister, R. & Plotnikoff, R.C. (2012). Preventing obesity among adolescent girls: One-year outcomes of the Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) cluster randomised controlled trial. *Archives of Pediatrics and Adolescent Medicine*, 166(9), 821–827.

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Major Findings

This paper reports the 12-month primary outcomes, and summary variables for secondary outcomes for the NEAT Girls intervention. After 12-months, favourable but non-significant intervention effects were reported for changes in BMI (-0.19kg/m^2 ; 95% CI, -0.70 to 0.33), BMI z -score (-0.08 ; 95% CI, -0.20 to 0.04) and percentage body fat (-1.09 ; 95% CI, -2.88 to 0.70). Favourable changes in screen time (-31 minutes/day; CI, -62 to -1) were statistically significant. However, no intervention effects were found for the physical activity (accelerometer CPM, MVPA minutes/day), dietary (kcal/kg/day) or self-esteem outcomes.

7.1 Introduction

Obesity prevention is a global health priority (Wang, Chyen, Lee & Lowry, 2008) because paediatric weight status is associated with a range of adverse health outcomes (Denney-Wilson, Hardy, Dobbins, Okely & Baur, 2008; Gill, Bauer & Bauman, 2009; Reilly & Kelly, 2011) and obese youth are at an elevated risk for obesity in adulthood (Singh et al., 2008). The prevalence of child and adolescent obesity has increased considerably over the past 30 years and current estimates suggest that approximately one quarter of youth in developed nations are overweight or obese (Lobstein & Frelut, 2003; Ogden, Carroll, Curtin, Lamb & Flegal, 2010). Although there is evidence to suggest that levels of obesity have plateaued in recent years (Olds et al., 2010), this trend has not been observed among youth living in low-income communities (Hardy et al., 2011; Stamatakis et al., 2010).

Schools have been identified as important institutions for the promotion of healthy lifestyles (Brown & Summerbell, 2009) and provide access to populations at risk of obesity, such as adolescents living in low-income communities. Although evidence for the long-term effects of school-based obesity prevention programs is limited (Jones et al., 2011), recent high quality studies have demonstrated that these interventions can prevent unhealthy weight gain in youth (Foster et al., 2010; Lubans, Morgan, Aguiar & Callister, 2011; Singh et al., 2009). Multi-component school-based interventions targeting groups at risk of obesity can be effective, but further testing in long-term rigorously designed studies is needed (Brown & Summerbell, 2009; Katz et al., 2008).

The importance of designing and implementing obesity prevention programs for pre-adolescent and adolescent girls living in low-income communities has emerged in the literature (Klesges et al., 2010; Neumark-Sztainer et al., 2010; Robinson et al., 2010). The physical activity decline associated with adolescence is steeper among girls (Nader et al., 2008) and unhealthy weight gain is often observed in this cohort (Berkey, Rockett & Colditz, 2008; Eissa et al., 2009). Hence, the aim of the current study was to evaluate the effects of the NEAT Girls program (Lubans, Morgan, Dewar et al., 2010). NEAT Girls was a 12-month school-based group RCT designed to prevent unhealthy weight

gain in adolescent girls living in low-income communities. This paper reports the 12-month effects for the NEAT Girls intervention.

7.2 Methods

7.2.1 Study Design and Participants

Ethics approval for the study was obtained from the relevant university and school board human ethics committees. School Principals, parents and study participants provided written informed consent. The design, methods and characteristics of participants at baseline have been reported in detail elsewhere (Lubans, Morgan, Dewar et al., 2010). In summary, NEAT Girls was a group RCT. The design, conduct and reporting of the trial adhere to the CONSORT guidelines (Schultz et al., 2010). Baseline assessments were conducted in May/June 2010 and 12-month (immediate post-test) assessments were completed in May/June 2011.

The intervention was designed for adolescent girls from schools located in low-income communities and the SEIFA index of relative socio-economic disadvantage was used to identify eligible secondary schools. The SEIFA index (scale 1 = lowest to 10 = highest) summarises the characteristics of people and households within an area. State funded government secondary schools located in the Hunter Region and Central Coast areas in NSW with a SEIFA index of ≤ 5 (bottom 50%) were considered eligible for inclusion. Eighteen schools in the Central Coast and Hunter regions met our eligibility criteria and all of these schools were invited to participate. Twelve secondary schools were recruited and eligible study participants were adolescent girls in Grade 8 (2nd year of secondary school).

7.2.2 Sample Size Calculation and Randomisation

The sample size calculation was based on change in BMI (Cole, Faith, Pietrobelli & Heo, 2005). Assuming an α of 0.05, power of 80% and a 20% dropout, we calculated that we would require 30 participants from each of the 12 schools to detect a between-group difference of one BMI unit (Robinson et al., 2008), using a BMI standard deviation of 1.5 kg/m² (Singh et al., 2009) and an ICC of 0.01 (Amorim et al., 2007).

Following baseline assessments, the 12 schools were matched (i.e., six pairs of schools) based on their geographical location, size and demographics (Murray, 1998). An independent researcher then randomised each pair to either the NEAT Girls intervention or the control group.

7.2.3 Intervention

The NEAT Girls intervention was informed by the Program X pilot study (Lubans, Morgan, Callister et al., 2009; Lubans, Morgan, Callister, Collins & Plotnikoff, 2010) and a detailed description of the intervention has been reported previously (Lubans, Morgan, Dewar et al., 2010). The intervention was guided by Bandura's SCT (1986) and targeted evidence-based psychological (i.e., self-efficacy, outcome expectations, outcome expectancies), behavioural (i.e., goal setting and self-monitoring) and environmental (i.e., teacher, family and peer support) influences on physical activity and nutrition behaviour change (Cerin et al., 2009; Lubans et al., 2008).

The intervention included the following components: enhanced school sport sessions, interactive seminars, nutrition workshops, lunchtime physical activity sessions, handbooks and pedometers for self-monitoring, parent newsletters, and text messaging for social support. To facilitate the implementation of the NEAT Girls program, school champions (i.e., teachers responsible for part-delivery of the program) from the intervention schools attended a one-day training workshop at the local university. The intervention was focused on the promotion of lifetime physical activities, reducing sedentary behaviours and low-cost healthy eating and was delivered over four school terms (i.e., 12-months) at no additional financial cost to the school or students. All intervention schools were provided with a standard equipment pack (value = \$US1300), which consisted of a range of equipment (e.g., elastic tubing resistance training devices, fit balls, Yoga and Pilates resources) designed to support the promotion of lifetime physical activities.

NEAT Girls was based on well-defined messages designed to promote physical activity and healthy eating and reduce sedentary behaviour (Lubans, Morgan, Dewar et al., 2010), which were reinforced using the intervention components. The enhanced school sport sessions (approximately 90 minutes each) were delivered by teachers and involved

a range of activities organised into four-week units. For the first school term, the enhanced school sport sessions included an information component (10–15 minutes) delivered by teachers from the study schools. Members of the research team delivered three interactive seminars that focused on the benefits of physical activity and healthy eating and the key behavioural messages. Participants were also provided with pedometers (Lubans, Morgan & Tudor-Locke, 2009) and handbooks to monitor their lifestyle physical activity (e.g., daily pedometer step counts) and key dietary behaviours (e.g., daily servings of fruit) in relation to recommendations for these behaviours.

Three nutrition workshops were delivered in the intervention schools by APDs. The sessions were designed to provide students with the confidence to select, prepare and consume healthy, low-cost foods. Parents of participants were sent newsletters at four periods over the 12-month intervention. The first newsletter reported their child's time spent in physical activity, sedentary behaviours, and self-reported fruit and vegetable consumption. All of the newsletters included information to raise awareness and encourage parents to support their children's physical activity and dietary behaviours. To reinforce the targeted health behaviours, the girls were sent text messages weekly during the second and third terms and bi-weekly during the fourth term of the program's delivery (e.g., *'Sitting down for long periods of time is bad for you, but what makes it worse is that people often eat junk while sitting down in front of the TV. Try to avoid eating dinner while watching TV'*). Finally, to assist in the recruitment of schools and to prevent resentful demoralisation or compensatory rivalry (Murray, 1998), the control group was provided with equipment packs and a condensed version of the intervention following the completion of 24-month assessments.

7.2.4 Outcome Measures

Data collection took place in the study schools and was conducted by trained RAs blinded to group allocation at baseline only.

Primary outcome. BMI was the primary outcome and was calculated using the standard equation ($\text{weight}[\text{kg}]/\text{height}[\text{m}]^2$). Weight was measured in light clothing without shoes using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) and height was measured using a portable stadiometer (Model no. PE087, Mentone

Educational Centre, Australia). BMI weight categories were based on BMI z-scores, which were calculated using the 'LMS' method (Cole et al., 2000).

Secondary outcomes. Percentage body fat was determined using the ImpTM SFB7 bioelectrical impedance analyser (Lubans, Morgan, Callister et al., 2011). The 90° push-up and the prone support tests (Cooper Institute for Aerobics Research, 1992) were used to provide measures of upper body muscular endurance and core abdominal isometric muscular endurance, respectively. Participants wore ActiGraph accelerometers (MTI models 7164, GT1M and GT3X) for seven consecutive days. Trained RAs fitted the monitors and explained the monitoring procedures to participants as described by Trost et al., (2005). Participant data were included in the analyses if accelerometers were worn for ≥ 600 minutes on ≥ 4 days (including one weekend day) (Trost et al., 2000). Data were collected in 30-second epochs and cut-points were used to categorise age- and sex-related activity intensity (Freedson et al., 2005). Dietary intake was assessed using the previously validated Australian Eating Survey FFQ (i.e., total kilojoules/day and total kilojoules/kg/day is presented here as a summary variable to represent dietary intake) (Watson et al., 2009). The ASAQ was used to provide a self-report measure of screen time (i.e., daily minutes spent watching TV/videos/DVDs, computers, and e-communication) (Hardy, Booth et al., 2007). Participants also completed selected scales from Marsh's Physical Self-Description Questionnaire, which included assessments of perceived body fatness, physical self-esteem and global self-esteem (Marsh et al., 1994).

Finally, a detailed process evaluation was conducted. This included: attendance/reach (i.e., attendance at enhanced school sport, lunchtime physical activities and nutrition workshops; percentage of students who provided postal addresses, mobile phone numbers and were sent all four newsletters and the 58 text messages); intervention fidelity (i.e., 24 randomly selected enhanced school sport sessions were observed by a member of the research team); and program satisfaction (i.e., girls completed detailed process evaluation questionnaires at the completion of the study). The fidelity of each observed enhanced school sport session was assessed using the following criteria: 1) was there $\geq 60\%$ student attendance at the session; 2) was the session delivered by the school champion; 3) did the school champion deliver the session using the program handbook; and 4) did the session follow the basic structure outlined in the handbook?

7.2.5 Statistical Analysis

Differences between groups at baseline were examined with chi square and independent samples *t*-tests using PASW Statistics 17 software (SPSS Inc. Chicago, IL), and alpha levels were set at $p < .05$. Statistical analyses followed the intention-to-treat principle and were conducted using mixed models, which have the advantage of being robust to the biases of missing data (Mallinckrodt et al., 2004). The models were specified to adjust for the clustered nature of the data and the analysis was conducted using established models (Murray, 1998). The mixed models were analysed using the PROC MIXED statement in SAS V9.1 (SAS Institute Inc Cary NC).

7.3 Results

School and participant recruitment, enrolment and flow are provided in Figure 7.1. Twelve schools were recruited and 357 participants were assessed at baseline, representing 99.2% of the targeted sample size. There were no statistically significant differences between intervention and control groups for any of the outcomes at baseline. Sixty-three girls were unavailable for 12-month assessments, leaving 153 (85.5%) and 141 (79.2%) girls in the control and intervention groups, respectively. The girls who dropped out of the study had higher baseline BMI (mean [*SD*], 23.81 [4.52] versus 22.39 [4.56], $p = .025$) and BMI z-score (1.11 [1.06] versus 0.73 [1.15], $p = .019$) values than study completers.

7.3.1 Primary and Secondary Outcomes

Outcomes are reported in Table 7.1. Changes in body composition were all in favour of the intervention group, but there were no statistically significant between-group differences in BMI (primary outcome), BMI z-score or percentage body fat. Girls in the intervention group reported significantly less screen time than girls in the control group (adjusted mean difference [95% CI] = -30.67 mins/day, [-62.43 to -1.06]). Compliance with our accelerometer monitoring was poor (i.e., 191 [53.5%] and 89 [24.9%] participants wore accelerometers for ≥ 600 minutes on ≥ 4 days including a weekend day at baseline and post-test) and there were no differences between groups on any of the

physical activity outcomes. Muscular fitness, dietary intake, physical self-perceptions and self-esteem remained relatively stable over the study period for both intervention and control girls with no differences between groups.

7.3.2 Intervention Implementation and Process Outcomes

A total of 148 girls received the intervention (83.1% of initial intervention group). Students' mean attendance at school sport sessions was 61%. On average, girls attended 65% of the nutrition workshops, 25% of the optional lunchtime sessions, and completed 9% of the physical activity and nutrition home challenges. Intervention delivery fidelity was found to be 74%. All four of the parental newsletters were sent to valid addresses for 75% of girls in the intervention group. A total of 58 text messages were sent to 91% of girls in the intervention group. Overall, girls were satisfied with the program (mean [SD] 3.52 [1.24], 1 = *Strongly disagree* to 5 = *Strong agree*). The enhanced school sport sessions and nutrition workshops were rated the most favoured intervention components by 41.7% and 38.7% of girls respectively. No injuries or adverse effects were reported during the activity sessions or assessments.

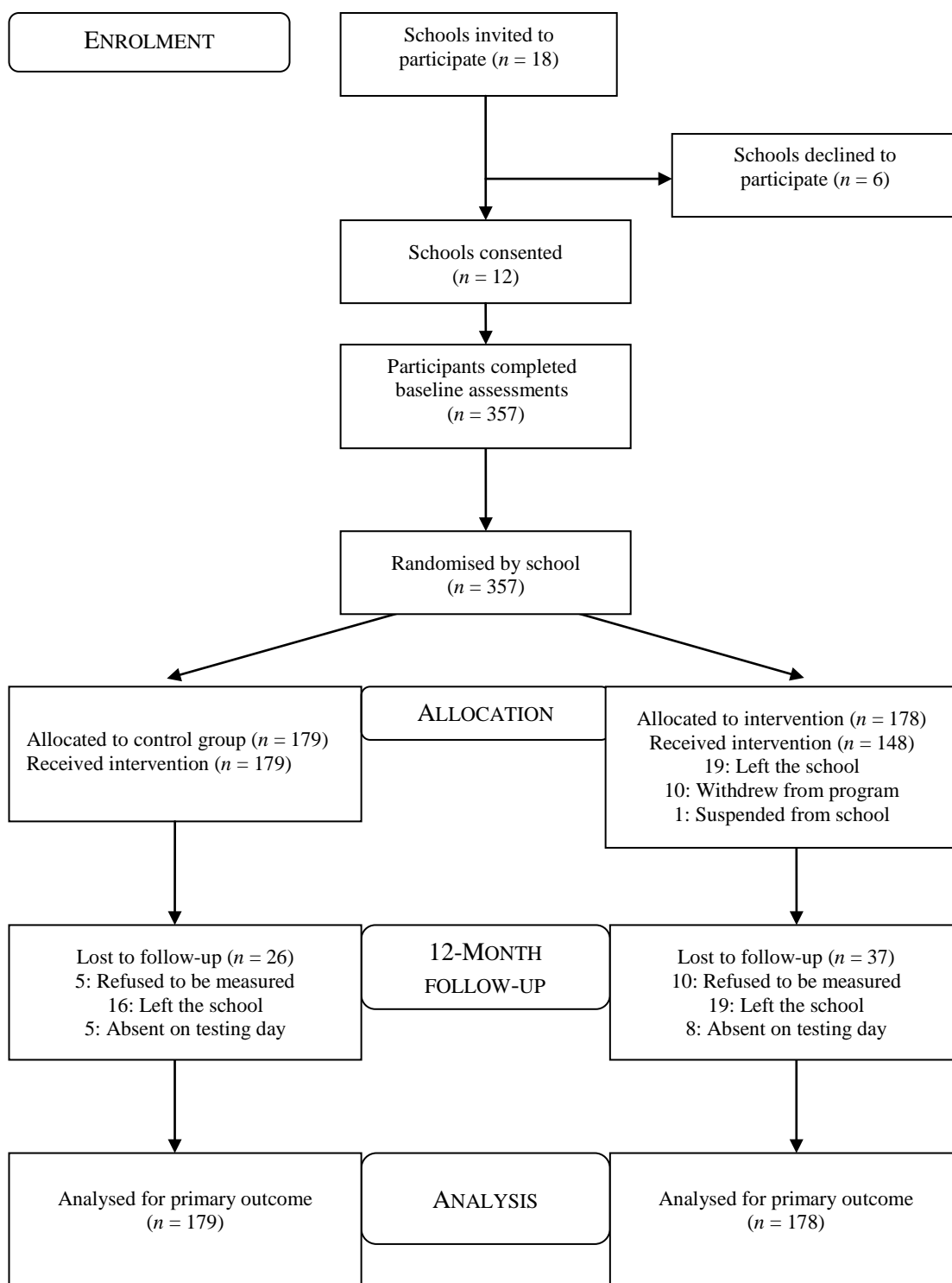


Figure 7.1: Flow of participants through the study

Table 7.1: Changes in primary and secondary outcome measures and group differences

Measure	Baseline, Mean (<i>SD</i>)		12 Month, Mean (<i>SD</i>)		Adjusted Difference in Change (95% CI) ^a
	Control Group (<i>n</i> = 179)	Intervention Group (<i>n</i> = 178)	Control Group (<i>n</i> = 153)	Intervention Group (<i>n</i> = 141)	
BMI (kg/m ²)	22.59 (4.49)	22.70 (4.7)	23.37 (4.68)	23.30 (4.71)	−0.19 (−0.70 to 0.33) †
BMI <i>z</i> -score	0.78 (1.16)	0.82 (1.12)	0.81 (1.17)	0.76 (1.16)	−0.08 (−0.20 to 0.04) †
Body fat (%)	28.3 (6.8)	29.6 (6.5)	32.6 (5.9)	32.7 (5.9)	−1.1 (−2.9 to 0.7) †
Push-up test (repetitions) ^b	11 (6 to 16)	10 (6 to 16)	10 (6 to 16)	11 (7 to 19)	2.38 (−2.47 to 7.22) †
Prone support test (seconds) ^b	36.8 (25.6 to 64.2)	44.0 (28.4 to 67.0)	42.8 (26.0 to 62.0)	50.0 (31.8 to 69.0)	−4.44 (−17.93 to 9.04)
Accelerometer CPM ^{b,c}	363.0 (313.2 to 568.9)	388.6 (310.8 to 459.7)	360.1 (265.0 to 452.6)	322.1 (270.5 to 392.7)	−46.19 (−123.26 to 31.88)
MVPA (<i>min/day</i>) ^{b,c}	32.0 (24.7 to 42.1)	33.5 (20.5 to 40.1)	25.0 (16.5 to 41.7)	21.5 (15.9 to 28.9)	−4.28 (−13.82 to 5.25)
Screen time daily (<i>min/day</i>) ^b	220.7 (162.7 to 341.8)	240.0 (161.8 to 368.6)	248.6 (177.9 to 355.7)	231.4 (161.8 to 375.4)	−30.67 (−62.43 to −1.06)*†
Screen time weekday (<i>min/day</i>) ^b	209.0 (156.0 to 289.0)	216.0 (142.5 to 349.5)	236.0 (156.0 to 333.5)	222.0 (142.5 to 326.1)	−25.39(−54.14 to 3.36)†
Screen time weekend (<i>min/day</i>) ^b	255.0 (150.0 to 420.0)	300.0 (178.8 to 450.0)	300.0 (180.0 to 608.0)	285.0 (180.0 to 420.0)	−42.90 (−100.41 to 14.61)†
Mean daily energy intake (<i>kcal/day</i>)	2241.2 (1259.8)	2598.8 (1763.6)	2233.8 (1551.9)	2524.8 (1610.0)	−62.0 (−464.2 to 340.3)†
Adjusted mean daily energy intake (<i>kcal/kg/day</i>) ^b	36.7 (106.4 to 214.2)	35.6 (110.4 to 222.3)	33.1 (93.9 to 193.6)	35.65 (98.4 to 226.5)	−0.52 (−7.31 to 6.27)†
Perceived body fatness (<i>low = 1 to high = 5</i>)	3.88 (1.51)	3.75 (1.48)	3.78 (1.46)	3.84 (1.49)	0.19 (−0.10 to 0.47) †
Physical self-esteem (<i>low = 1 to high = 5</i>)	3.74 (1.25)	3.71 (1.26)	3.63 (1.17)	3.75 (1.28)	0.17 (−0.15 to 0.48) †
Global self-esteem (<i>low = 1 to high = 5</i>)	4.28 (1.01)	4.16 (1.09)	4.29 (0.99)	4.09 (1.10)	−0.08 (−0.30 to 0.14)

Note: Abbreviations: BMI, body mass index; CI, confidence interval; CPM, Counts per minute; MVPA, moderate-to-vigorous physical activity; ^aAdjusted mean difference and 95% CI between NEAT Girls and control groups after 12-months (intervention minus control); ^bData were transformed due to non-normality, median and interquartile range provided; ^c191 and 89 participants wore accelerometers for ≥600 minutes on ≥4 days including a weekend day at baseline and post-test, respectively; **p* < .01; †Changes in favour of the intervention group.

7.4 Discussion

NEAT Girls was a multi-component school-based obesity prevention program targeting adolescent girls from secondary schools located in low-income communities. The intervention effects on body composition were small and not statistically significant, but have potential clinical importance. Girls in the intervention group spent 30 mins/day less in screen-based activities than their control group peers. High levels of screen time are associated with a range of adverse health consequences (Salmon et al., 2011) and our findings have important implications that may help address the increasing burden of paediatric and adolescent obesity observed in areas of social and economic disadvantage.

Behaviours, attitudes and physical morbidity that develop during adolescence have profound implications for current and future health (Steinbeck et al., 2009), yet surprisingly few adolescent obesity prevention programs have been designed and evaluated (Waters et al., 2011). The challenges of working with adolescents (Steinbeck et al., 2009) may explain both the small number of studies and their modest results. Small differences can be meaningful at the population level, and the favourable changes in BMI z-score (-0.08 [-0.20 to 0.04]) and percentage body fat (-1.1 [-2.9 to 0.7]) observed in our study may have clinical significance and important public health implications. A recent longitudinal study found that a 1% increase in percentage body fat was related to increases of 1.042 mg/dL and 0.621 mg/dL in total cholesterol in boys and girls, respectively (Dai et al., 2009). Similarly, the school-based diabetes risk reduction intervention, known as the HEALTHY study, resulted in a small but statistically significant reduction in BMI z-score (i.e., -0.05), which was accompanied by smaller increases in fasting insulin levels (i.e., 4.0 U/ml in control group versus 3.8 U/ml in the intervention group) (Foster et al., 2010). Increases in body fatness during youth are consistently associated with adverse changes in plasma lipids (Dai et al., 2009; Freedman, Dietz, Srinivasan & Berenson, 1999) and further examination of the health implications of weight gain during this period will help to determine the clinical importance of intervention effects.

A number of recent obesity prevention interventions targeting adolescent and pre-adolescent girls have been evaluated in the school and community settings. The New

Moves intervention (Neumark-Sztainer et al., 2003) was similar in size and intervention design to the NEAT Girls program, but improvements in body composition were half the magnitude to those observed in our study (adjusted difference in BMI and percentage body fat -0.10 and -0.46 , respectively). The Stanford and Memphis GEMS interventions (Klesges et al., 2010; Robinson et al., 2010) were well-designed obesity prevention interventions targeting unhealthy weight gain in pre-adolescent girls from low-income communities. The interventions resulted in positive changes in fasting total cholesterol levels and depressive symptoms, although there were no treatment effects for BMI. Although both schools and community settings offer promise for the prevention of obesity in youth (Brown & Summerbell, 2009), more work is needed to translate the strong effects typically observed in small-scale efficacy studies to large-scale effectiveness trials.

Girls in the intervention group did not increase their physical activity, but significant differences in screen time were observed over the study period. The large reductions in self-reported screen time represent one-quarter of participants' daily limit and such changes have important health implications. Young people spend two to four hours per day in screen-based recreation and five to 10 hours per day sedentary, both of which are associated with a range of adverse health consequences (Salmon et al., 2011). Targeting time spent in sedentary behaviour has emerged as an effective strategy for preventing unhealthy weight gain in youth (Epstein, Paluch, Gordy & Dorn, 2000; Epstein et al., 2008). Screen time is associated with unhealthy dietary behaviours in youth (Pearson & Biddle, 2011) and the reductions in screen time observed in the intervention group may have helped to reduce energy intake. Although we did not observe clinically important changes in total energy intake, this could be due to the lack of sensitivity in the FFQ used in our study.

Culturally appropriate obesity prevention interventions appear to be more effective than those that disregard cultural identity (Wilson, 2009). Although NEAT Girls was not targeted towards a specific cultural group, the importance of addressing cultural uniqueness is relevant to our study and we employed a number of strategies to ensure that the intervention was tailored and relevant to the participants. For example, the intervention logo and materials were branded and tailored to appeal to adolescent girls. A variety of novel strategies were used to engage girls in the interactive seminars (e.g.,

game show format) and participants were encouraged to bring their own music to be played on a portable digital music player during the enhanced school sport and lunchtime physical activity sessions. The enhanced sports sessions focused on lifetime activities that are appealing to adolescent girls and the nutrition workshops involved the preparation of inexpensive healthy snacks and meals. Both the enhanced school sport sessions and the nutrition workshops were rated favourably by girls, but the attendance at sessions was not as high as anticipated. NEAT Girls involved parental newsletters and home challenges to engage parents in the intervention, but we did not survey parents and cannot determine if parental behaviours and support changed as a result of the intervention.

The strengths of this study include the group RCT design, the monitoring of intervention compliance, the unique study population and the high level of participant retention. However, there are some limitations that should be noted. First, despite employing a number of strategies to improve monitoring compliance, only a small number of participants provided usable accelerometer data at baseline (53.5%) and post-test (24.9%). Second, dietary intake was assessed using a FFQ, which lacks sensitivity to detect small changes in energy intake. Third, we underestimated the school level ICC for the body composition variables, which resulted in reduced statistical power. Given the higher than expected ICC and the small number of clusters, we conducted additional statistical analyses that adjusted for the clustered nature of the data, but did not include 'time' as a random effect. In these models we found a significant intervention effect for percentage body fat ($p = .024$) and a marginally significant effect BMI z-score ($p = .099$). Finally, screen time was measured using self-report and the results may be influenced by experimenter expectancies and evaluation apprehension.

7.5 Conclusion

In summary, 12-month outcomes show the NEAT Girls intervention resulted in small improvements in body composition and large reductions in self-reported screen time. Our findings demonstrate the potential for multi-component school-based interventions for the prevention of unhealthy weight gain in adolescent girls attending schools in low-income communities.

Chapter 8: One-year Outcomes of the NEAT Girls Obesity Prevention Intervention: Part Two

Dewar, D. L., Morgan, P. J., Plotnikoff, R. C., Okely, A. D., Batterham, M. & Lubans, D. R. (2014). Exploring changes in physical activity, sedentary behaviours and hypothesised mediators in the NEAT Girls group randomised controlled trial. *Journal of Science and Medicine in Sport*, 17(1), 39-46.

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Major Findings

This paper reports a detailed breakdown of 12-month secondary outcomes for physical activity, sedentary behaviour and hypothesised mediators of physical activity behaviours. After 12-months, positive and statistically significant intervention effects were found for self-reported recreational computer use (–26.0 minutes/day; 95% CI, –46.9 to –5.1), and self-reported sedentary activities summed (–56 minutes/day; 95% CI, –110 to –3); however, objectively measured sedentary behaviour showed no differences. No significant group-by-time effects for any of the physical activity outcomes or hypothesised mediators were found.

8.1 Introduction

Considering the adverse consequences of obesity (Denney-Wilson, Hardy, Dobbins, Okely & Baur, 2008; Gill, Bauer & Bauman, 2009; Reilly & Kelly, 2011; Wake et al., 2011) and the high likelihood of obesity persisting from adolescence into adulthood (Singh et al., 2008), obesity prevention is a global health priority. However, evidence for effective obesity prevention and treatment interventions targeting youth have been limited by a lack of high quality of studies. Methodological weaknesses of previous studies include the lack of a theoretical framework to guide behaviour change, self-reported outcome measures, inadequate intervention duration and/or intensity, poor program compliance and short-term follow-up (Waters et al., 2011). Further, few obesity prevention interventions have examined hypothesised mediators of intervention effects on targeted behaviours such as physical activity (Lubans et al., 2008). This process is important for establishing the causal mechanisms of behaviour change, which can inform the design and delivery of more effective programs in the future. Clearly, the evaluation of more rigorously designed studies for adolescents is needed.

Evidence suggests that multi-component, school-based interventions that target behaviour change at multiple levels can prevent short-term unhealthy weight gain (Brown & Summerbell, 2009). Moreover, it has been indicated that these interventions may be more efficacious if targeted towards certain groups and differentiated on the basis of sex, age and SEP (Cale & Harris, 2006). Despite higher levels of obesity and overweight typically observed in areas of social and economic disadvantage (Stamatakis et al., 2010), few school-based interventions have targeted youth of low-SEP. The transition from childhood to adolescence is characterised by a marked deterioration in physical activity and dietary behaviours (Nader et al., 2008). Moreover, higher levels of sedentary behaviour and poorer dietary and physical activity behaviours are often found for those living in low-income communities, especially in girls (Brodersen et al., 2007; Cutler et al., 2011), placing this group at an even greater risk of obesity.

The current study aims to address the limitations of previous obesity-related prevention interventions that have targeted adolescents. The NEAT Girls program was a 12-month school-based group RCT designed to prevent unhealthy weight gain in adolescent girls

of low-SEP through improving physical activity, dietary and sedentary behaviours. The impact of the NEAT Girls intervention on the study's primary outcome (BMI) has been reported elsewhere (Lubans et al., 2012). This paper provides a comprehensive report of the 12-month intervention effects on secondary outcomes including 1) time spent in moderate (MPA), vigorous (VPA) and MVPA within and beyond the school day; 2) time spent in total and selected screen-based and non-screen-based sedentary behaviours; and 3) hypothesised social cognitive mediators of physical activity behaviour change.

8.2 Methods

Detail of the NEAT Girls study design, methods and participant characteristics at baseline have been described previously (Lubans, Morgan, Dewar et al., 2010). Briefly, the intervention is a 12-month school-based group RCT with a 12- and 24-month follow-up. The program was developed for adolescent girls attending public secondary schools located in low-income communities as determined by SEIFA Index deciles (ABS, 2001). Schools were eligible to participate if located in areas that had an allocated SEIFA index of ≤ 5 (bottom 50%). Eighteen schools were randomly selected from a list of eligible schools in the Hunter, Newcastle and Central Coast areas in NSW, Australia. If the first school on the list declined, the next school was invited and this iterative process continued until 12 schools had been recruited. Study participants were in Grade 8 at the time of recruitment. Ethics approval was obtained from the relevant institutional boards. Written consent was obtained from the Principal of recruited schools, study participants and their parents. A sample size calculation is described elsewhere (Lubans, Morgan, Dewar et al., 2010), but was based on change in BMI being the primary outcome for the NEAT Girls intervention. Baseline and 12-month (program conclusion) assessments were collected during May and June in 2011 and 2012. Following baseline assessments, schools were match paired based on their size, geographic location and demographics. Schools within each pair were then randomised by an individual not involved in the project to either the NEAT Girls intervention or a wait list control group.

Bandura's SCT (1986) provided the theoretical framework for the program. The intervention targeted the following psychological, behavioural and environmental influences on physical activity: self-efficacy, social support, behavioural strategies, perceived physical environment, outcome expectations and expectancies. The program involved multiple components. Teachers delivered the enhanced school sport sessions and lunchtime physical activity sessions. APDs delivered the nutrition workshops, and members of the research team delivered the interactive educational seminars and distributed text messages to reinforce and encourage targeted health behaviours. The enhanced school sport sessions and nutrition workshops were implemented during existing timetabled school sport, while the lunchtime sessions provided additional opportunity for physical activity. All intervention materials were developed by the research team. Teachers from the intervention schools attended a full-day training workshop designed to support program implementation in their school. An outline of the intervention strategies, hypothesised social cognitive mediators of physical activity behaviour change and their respective measures is provided in Table 8.1.

8.2.1 Outcome Measures

Physical activity. Participants wore ActiGraph accelerometers [MTI models 7164, GT1M and GT3X (ActiGraph, LLC, Fort Walton Beach, FL)] positioned on their hip for seven consecutive days during waking hours, except during aquatic activities. Accelerometers were distributed to participants for immediate wearing on the same day that all other assessments were conducted. Comparisons of the output generated by the various ActiGraph accelerometers suggest that the data are comparable for estimating physical activity (John et al., 2010). Uniaxial data were collected in 30-second epochs and activity thresholds were used to calculate time spent sedentary (≤ 50 counts) and in MPA (1148–2005 counts) and VPA (≥ 2006 counts) (Trost et al., 2011). Strings of consecutive 0 counts ≥ 20 minutes were defined as non-wear time and were subsequently removed during data reduction. Data were included in the analyses if a participant wore the monitor for at least 600 minutes per day for at least three days, including a weekend day. Data were reduced to obtain physical activity outcomes for the following given periods: total wear time, weekdays, school hours and after school hours. These specific periods were of interest because the intervention provided increased opportunity for physical activity during school hours, and strategies were

employed to promote participation in physical activity during the critical opportune time interval immediately after school. After school hours was determined as the period from when school ended for each participant (which ranged from 2.05pm and 3.20pm) to 6.00pm. To account for differences in wear time and school start and finish times, the outcomes used in the analyses were mean CPM and percentage of time in MPA, VPA and MVPA.

Sedentary behaviour. Sedentary behaviours were assessed using accelerometers and the previously validated ASAQ (Lubans, Hesketh et al., 2011), which provided self-reported time spent in a variety of sedentary activities over the last seven days. These included watching TV and DVDs, recreational computer use, inactive travel (i.e., by car/bus/train) and inactive socialising (i.e., sitting while talking on the phone or with friends). A composite variable summing all sedentary activities assessed was also calculated. A daily average for each sedentary activity variable was then determined.

Social-cognitive scales. Six social-cognitive scales assessed self-efficacy, perceived environment, social support, behavioural strategies, outcome expectations and outcome expectancies related to physical activity. Specifically, the referent for each scale was regular MVPA which was defined as '*participating in a total of 60 minutes of at least moderate-intensity activity on all or most days of the week*'. The scales were previously tested in an adolescent sample ($n = 171$, mean age 13.6 [1.2] years) (Dewar et al., 2013). A description of each scale and its psychometric properties are reported in Table 8.1.

8.2.2 Data Analyses

Chi square and independent sample t -tests [PASW Statistics 17 (SPSS Inc)] were used to explore baseline group differences for each of the variables ($p < .05$). The analysis followed the intention-to-treat principle and was conducted using established linear mixed models, which were adjusted for the clustered nature of the data (i.e., school level was included in the models). Accelerometer derived outcomes were also adjusted for the different accelerometer models used. SAS version 9.1 (SAS Institute Inc.) was used to analyse the mixed models using the PROC MIXED statement.

Table 8.1: Hypothesised mediators, intervention strategies and scale descriptions

Hypothesised mediators	Intervention strategies	Description of scales	Range (No. of items)	Psychometric properties
Self-efficacy	<ul style="list-style-type: none"> • <i>Enhanced school sport sessions (40 x 90 minutes)</i>: Skill development through teacher-directed sessions focusing on enjoyable lifetime activities ~ Pilates, yoga, dance aerobics, resistance training using elastic tubing, boxing style fitness, circuit training and pedometer activities. • <i>Lunchtime physical activity (30 x 30 minutes)</i>: Student-directed sessions. Participants are encouraged to recruit and instruct younger peers in a range of lifetime physical activities. • <i>Student handbook</i>: Building confidence to adopt healthy behaviours through strategies to increase and overcome barriers to physical activity, and decrease sedentary behaviours. Includes 10 weekly home challenges that promote physical activity and reduce sedentary behaviours. • <i>Interactive seminars (3 x 30 minutes)</i>: Building confidence to adopt healthy behaviours through strategies to increase and overcome barriers to physical activity, and decrease sedentary behaviours. • <i>Parent newsletters (4)</i>: Information and strategies to support physical activity and decrease sedentary behaviours at home. • <i>Text messages (distributed once weekly during the second term, and twice weekly during the third and fourth term of the study)</i>: Encouraging participants to be physically active and reduce sedentary behaviours and suggest strategies to reinforce these behaviours. 	The scale examined confidence in ability to adopt and maintain participation in MVPA and overcome barriers to MVPA. For example, ' <i>I can still find the time to be physically active even when I've had a busy day</i> ', (1 = strongly disagree to 6 = strongly agree)	1–6 (5)	ICC = 0.91, α = 0.69, CFI = 0.99, RMSEA = 0.00
Behavioural strategies	<ul style="list-style-type: none"> • <i>Pedometers</i>: Encouraging goal setting and daily monitoring of physical activity behaviour. • <i>Interactive seminars</i>: Reinforcing key physical activity and SSR recommendations and suggesting strategies to increase physical activity and decrease sedentary behaviours. • <i>Student handbook</i>: Goal setting and daily monitoring of physical activity and small-screen behaviours guided by current recommendations. Strategies to increase physical activity and decrease sedentary behaviours. • <i>Text messages</i>: Regular messages that suggest strategies to increase physical activity and reduce sedentary behaviours. 	The scale examined the frequency with which personal approaches to enhancing enjoyment, setting goals and monitoring MVPA behaviours were employed in the past three months to reinforce participation in MVPA. For example, ' <i>... did you keep track of how much physical activity you did (e.g., by using a timer, pedometer or by keeping a logbook?)</i> ', (1 = never to 5 = always).	1–5 (6)	ICC = 0.91, α = 0.79, CFI = 0.97, RMSEA = 0.07

Perceived environment	<ul style="list-style-type: none"> • <i>Parent newsletters</i>: Strategies and resources to support physical activity participation at home. • <i>Student handbooks</i>: Identifying opportunities for physical activity at home and in my neighbourhood/local area. • <i>Enhanced school sport sessions</i>: Provision of curriculum, equipment and instruction to support delivery of enjoyable lifetime physical activities. • <i>Lunchtime physical activity sessions</i>: Additional weekly opportunity to participate in enjoyable lifetime physical activities. 	<p>The scales examined participants mental representation of the following environments that may influence their participation in MVPA (<i>1 = strongly disagree to 6 = strongly agree</i>):</p> <p>a) Home/neighbourhood environment. For example, '<i>I have a place at home where I can be physically active (e.g., gym, backyard or the garage)</i>'.</p> <p>b) School environment. For example, '<i>At school there are facilities available during recess/lunch for me to be physically active (e.g., the gym, dance studio, courts or oval)</i>'.</p>	<p>1–6 (3)</p> <p>1–6 (3)</p>	<p>ICC = 0.88, α = 0.63, CFI = 0.98, RMSEA = 0.05</p> <p>ICC = 0.85, α = 0.65, CFI = 0.98, RMSEA = 0.05</p>
Social support	<ul style="list-style-type: none"> • <i>Text messages</i>: regular messages to encourage participation in physical activity and reduce sedentary behaviours. • <i>Parent newsletters</i>: encouraging parents to be active with children. • <i>Student handbook</i>: 10 weekly home challenges to complete with parents. • <i>Enhanced school sport sessions and lunchtime physical activity</i>: enjoyable lifetime physical activity experiences with friends. 	<p>The scales examined the frequency with which social support was received from significant others in the past three months that encouraged participation in MVPA (<i>1 = never to 5 = always</i>):</p> <p>a) Support from family. For example, '<i>... did members of your family take you to places where you could be physically active (e.g., to the beach, training, weekend sport, ice-skating rink)</i>'?</p> <p>b) Support from friends. For example, '<i>... did your friends participate in physical activities or sports with you during lunch, recess or after school?</i>'</p>	<p>1–5 (4)</p> <p>1–5 (4)</p>	<p>ICC = 0.86, α = 0.74, CFI = 0.98, RMSEA = 0.05</p> <p>ICC = 0.86, α = 0.74, CFI = 0.98, RMSEA = 0.05</p>

Outcome expectations	<ul style="list-style-type: none"> • <i>Enhanced school sport sessions and lunchtime physical activity:</i> enjoyable lifetime physical activity experiences with friends. • <i>Student handbook:</i> benefits of regular physical activity and health implications of physical inactivity and sedentary behaviours. • <i>Interactive seminars:</i> reinforcing the benefits/health implications of physical activity/inactivity and sedentary behaviours. 	The expectations scale examined anticipated physical, social and emotional benefits of participating in regular MVPA. For example, <i>'Participation in regular physical activity can help to improve my fitness', (1 = strongly disagree to 6 = strongly agree).</i>	1–6 (5)	ICC = 0.82, α = 0.75, CFI = 0.97, RMSEA = 0.09
and Outcome expectancies		The expectancies scale examined corresponding personal evaluations of the benefit identified by each outcome expectation item. For example, <i>'How important is improving your fitness to you?', (1 = not at all important to 4 = very important)</i>	1–4 (5)	ICC = 0.88, α = 0.66, CFI = 0.91, RMSEA = 0.11

Note: α = Cronbach's alpha; CFI, comparative fit index; ICC, Intra-class correlation for test-retest reliability; RMSEA, root mean square error of approximation

To test for mediation of hypothesised social-cognitive variables on physical activity behaviour, mediation analyses typically involve the following: 1) an action theory test (i.e., to determine impact of intervention on hypothesised mediators by regressing the hypothesised mediators onto the treatment variable); 2) a conceptual theory test (i.e., to examine an association between changes in potential mediators and dependent variable by regressing mediators and the dependent variable onto the treatment variable); and 3) a significance test of the mediated effect.

8.3 Results

The study sample is described in more detail elsewhere (Lubans, Morgan, Dewar et al., 2010). It included 357 adolescent girls ($M = 13.2$ [0.5] years). At baseline, the percentage of participants classified as overweight or obese were 26.1% and 16.8% respectively. A total of 246 girls met the physical activity inclusion criteria based on accelerometer wear time at baseline and/or 12-months (≥ 600 minutes per day for at least three days including a weekend day). This translates to 61.9% ($n = 221$) of the total sample at baseline and 24.6% ($n = 88$) at 12-months.

There were no significant group-by-time effects for any of the physical activity outcomes (see Table 8.2). Self-report data showed girls in the intervention group had a significantly greater reduction in recreational computer use (-26.0 min/day; 95% CI, -46.9 to -5.1 ; $p = .02$) and sedentary activities summed (-56.4 min/day; 95% CI -110.1 to -2.7 ; $p = .04$) than their control peers. The change in time for inactive travel was marginally in favour of the intervention group with a between-group difference of -8.6 min/day (95% CI, -18.1 to 1.0 , $p = .07$). However, results for objectively measured sedentary behaviour showed both groups remained relatively stable with time producing no between-group differences.

Although changes were in favour of the intervention group for most of the social-cognitive variables (exception for perceived environment at school and family support), there were no statistically significant group-by-time effects for any of the outcomes. Further, as the intervention effect on hypothesised mediators (i.e., action theory test) was not statistically significant we did not conduct conceptual theory tests or test the significance of the mediated effect.

Table 8.2: Changes in outcome measures and between-group differences

Measure	Baseline, Mean (95% CI)		12-Month, Mean (95% CI)		Adjusted Difference in Change (95% CI) ^a	Group*Time <i>p</i>
<i>Physical activity</i>	Control Group (<i>n</i> = 113)	Intervention Group (<i>n</i> = 108)	Control Group (<i>n</i> = 57)	Intervention Group (<i>n</i> = 31)		
Total Mean CPM ^b	389.45 (117.13 to 476.08)	414.25 (330.63 to 509.68)	346.32 (276.67 to 449.18)	342.19 (263.04 to 406.57)	-19.82 (-100.53 to 60.89)	0.59
Total MPA (%)	3.64 (3.06 to 4.23)	4.01 (3.42 to 4.60)	3.63 (3.05 to 4.23)	3.40 (2.75 to 4.04)	-0.61 (-1.71 to 0.49)	0.24
Total VPA (%)	1.09 (0.77 to 1.42)	1.05 (0.71 to 1.38)	0.90 (0.57 to 1.22)	0.82 (0.47 to 1.17)	-0.03 (-0.49 to 0.43)	0.87
Total MVPA (%) ^b	4.50 (3.28 to 5.73)	5.00 (3.50 to 6.40)	4.00 (2.80 to 6.15)	3.70 (2.85 to 5.40)	-0.62 (-2.08 to 0.84)	0.37
During school hours mean CPM	418.30 (359.19 to 477.40)	406.04 (345.92 to 466.16)	354.51 (294.97 to 414.04)	356.79 (294.26 to 419.31)	14.53 ^d (-62.06 to 91.12)	0.68
During school hours MPA (%)	4.16 (3.35 to 4.96)	4.34 (3.52 to 5.17)	3.64 (2.83 to 4.46)	3.73 (2.86 to 4.61)	-0.10 (-1.22 to 1.21)	0.87
During school hours VPA (%)	1.00 (0.58 to 1.42)	0.91 (0.49 to 1.34)	0.73 (0.31 to 1.16)	0.87 (0.43 to 1.31)	0.22 ^d (-0.32 to 0.77)	0.38
During school hours MVPA (%)	5.15 (4.00 to 6.31)	5.23 (4.08 to 6.42)	4.37 (3.21 to 5.54)	4.62 (3.39 to 5.85)	0.15 ^d (-1.52 to 1.82)	0.85
After school hours mean CPM	453.83 (399.08 to 508.58)	463.20 (407.29 to 519.11)	382.79 (326.23 to 439.34)	343.29 (279.03 to 407.55)	-48.87 (-151.17 to 53.43)	0.31
After school hours MPA (%)	4.13 (3.31 to 4.97)	4.48 (3.64 to 5.33)	3.38 (2.52 to 4.24)	2.78 (1.81 to 3.76)	-0.94 (-2.60 to 0.73)	0.24
After school hours VPA (%)	1.34 (0.95 to 1.73)	1.45 (1.05 to 1.85)	0.98 (0.58 to 1.39)	0.84 (0.38 to 1.30)	-0.25 (-0.99 to 0.49)	0.46
After school hours MVPA (%)	5.47 (4.38 to 6.57)	5.93 (4.81 to 7.04)	4.35 (3.22 to 5.48)	3.56 (2.28 to 4.84)	-1.24 (-3.35 to 0.88)	0.22
Week days mean CPM	432.21 (388.67 to 475.76)	421.67 (377.13 to 466.21)	382.51 (338.63 to 426.39)	365.95 (318.63 to 413.26)	-6.02 (-87.75 to 34.86)	0.84
Week days MPA (%)	4.11 (3.51 to 4.70)	4.36 (3.75 to 4.96)	3.89 (3.29 to 4.49)	3.58 (2.91 to 4.24)	-0.56 (-1.67 to 0.64)	0.28
Week days VPA (%)	1.17 (0.87 to 1.48)	1.09 (0.78 to 1.41)	0.90 (0.59 to 1.21)	0.91 (0.58 to 1.25)	0.09 ^d (-0.30 to 0.47)	0.62
Week days MVPA (%)	5.29 (4.46 to 6.11)	5.45 (4.60 to 6.29)	4.80 (3.96 to 5.63)	4.48 (3.57 to 5.39)	-0.48 (-1.86 to 0.90)	0.46

Measure	Baseline, Mean (95% CI)		12-Month, Mean (95% CI)		Adjusted Difference in Change (95% CI) ^a	Group* Time <i>P</i>
<i>Sedentary behaviours</i>	Control Group (<i>n</i> = 179)	Intervention Group (<i>n</i> = 178)	Control Group (<i>n</i> = 154)	Intervention Group (<i>n</i> = 142)		
TV (min/day) ^b	102.86 (68.75 to 149.79)	113.93 (68.57 to 171.43)	102.86 (64.29 to 145.71)	98.57 (55.71 to 152.14)	-5.52 ^d (-23.23 to 12.19)	0.50
DVD (min/day)	47.91 (37.29 to 58.54)	56.85 (46.16 to 67.55)	56.90 (45.81 to 67.98)	60.93 (49.51 to 72.35)	-4.90 ^d (-19.11 to 9.30)	0.46
Recreational computer use (min/day)	80.05 (64.37 to 95.73)	89.32 (73.56 to 105.07)	102.88 (86.58 to 119.19)	86.15 (69.22 to 103.08)	-26.00 ^{d†} (-46.94 to -5.06)	0.02
Inactive travel (min/day)	37.12 (29.88 to 44.37)	42.38 (35.12 to 49.63)	42.82 (35.33 to 50.31)	39.52 (31.87 to 47.18)	-8.55 ^{d††} (-18.10 to 1.00)	0.07
Inactive Socialising (min/day)	89.26 (73.68 to 104.84)	86.84 (71.05 to 102.64)	112.03 (85.36 to 118.05)	92.72 (75.75 to 109.69)	-6.57 ^d (-30.36 to 17.22)	0.55
Self-reported sedentary activities summed (min/day) ^b	367.43 (276.25 to 492.86)	390.71 (275.71 to 527.14)	411.79 (310.89 to 552.14)	381.43 (277.86 to 498.57)	-56.38 ^{d†} (-110.10 to -2.67)	0.04
Objective total Sedentary behaviour (%)	60.65 (58.36 to 62.94)	59.84 (57.50 to 62.18)	64.88 (62.47 to 67.26)	65.26 (62.59 to 67.92)	0.56 (-2.84 to 3.97)	0.72
<i>Social-cognitive variables</i>						
Self-efficacy ^b	3.80 (3.00 to 4.60)	3.60 (3.00 to 4.20)	4.00 (3.15 to 4.60)	3.80 (3.00 to 4.40)	0.002 ^d (-0.33 to 0.34)	0.99
Perceived environment (home/neighbourhood) ^b	5.00 (4.00 to 5.33)	4.67 (4.00 to 5.33)	5.00 (4.33 to 5.33)	5.00 (4.00 to 5.33)	0.04 ^d (-0.24 to 0.31)	0.77
Perceived environment (school) ^b	4.00 (3.33 to 4.33)	3.67 (3.00 to 4.00)	4.00 (3.33 to 4.75)	3.67 (3.00 to 4.33)	-0.24 (-0.55 to 0.06)	0.11
Social support (friend) ^b	3.00 (2.50 to 3.50)	2.86 (2.50 to 3.50)	3.00 (2.50 to 3.75)	3.00 (2.50 to 3.50)	0.08 ^d (-0.43 to 0.59)	0.73
Social Support (family) ^b	3.50 (2.75 to 4.25)	3.29 (2.75 to 4.00)	3.75 (3.00 to 4.25)	3.25 (2.25 to 3.75)	-0.31 (-0.68 to 0.07)	0.10
Behavioural strategies ^b	3.00 (2.33 to 3.67)	3.00 (2.50 to 3.33)	2.83 (2.46 to 3.67)	3.00 (2.33 to 3.50)	0.14 ^d (-0.21 to 0.50)	0.39
Outcome expectations ^b	5.10 (4.80 to 5.60)	5.00 (4.60 to 5.40)	5.00 (4.80 to 5.60)	5.00 (4.60 to 5.40)	0.01 ^d (-0.27 to 0.29)	0.94
Outcome expectancies ^b	3.33 (3.00 to 3.60)	3.20 (2.80 to 3.40)	3.20 (3.00 to 3.60)	3.10 (2.80 to 3.60)	0.03 ^d (-0.16 to 0.23)	0.73

Note: BMI, body mass index; CI, confidence interval; CPM, counts per minute; MPA, moderate physical activity; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity; ^aAdjusted mean difference and 95% CI between NEAT Girls and control groups after 12-months (intervention minus control); ^bData were transformed owing to non-normality; median and interquartile range provided; ^dChanges in favour of the intervention group; [†]*p*<0.05; ^{††}*p*<0.1.

8.4 Discussion

To our knowledge, this is the first RCT to evaluate a school-based obesity prevention program targeting adolescent girls of low-SEP in Australia. The intervention significantly reduced girls' time spent in self-reported sedentary activities. Specifically, girls in the intervention group reported less time in computer use for recreation (–26 min/day) and sedentary activities summed (–56 min/day) compared to girls in the control group. These changes may have important implications, as emerging evidence suggests that the adverse health outcomes associated with sedentary activities (e.g., overweight and obesity, metabolic syndrome) are independent of physical activity (Ekeland et al., 2006). While the current study placed more emphasis on reducing time spent in screen-based recreation than other sedentary behaviours, significant and marginally significant intervention effects were still observed for self-reported sedentary activities summed ($p = .04$) and inactive travel ($p = .07$) respectively. Meanwhile, no difference in objectively measured sedentary behaviour was observed. However, these findings could be due to social desirability bias that self-report measures are susceptible to, and the clear differences in the types of sedentary behaviour that both measures capture. While the self-report measure specifically examined time spent in SSR, inactive travel and inactive socialising, the accelerometer data captured total sedentary minutes, which potentially encompasses a vast array of sedentary activities by the participants that substantially extend beyond the activities that were included in the self-reported measure (e.g., time spent sitting in classrooms).

Despite careful design and implementation, the intervention did not impact upon any of the physical activity outcomes or hypothesised mediators of physical activity behaviour change. That is, no significant results were found for within or beyond school day physical activity. Besides a lack of an intervention effect, problematic measurement may help to explain these null findings. Accelerometers lack the sensitivity to detect non-ambulatory movements. Hence, these devices do not capture all types of physical activity, and this is a potential limitation for the current study considering the NEAT Girls intervention promoted a range of physical activities, some of which are non-ambulatory in nature (e.g., resistance training). Additionally, poor accelerometer compliance (61.9% and 24.6% at baseline and post-test respectively) has resulted in a

small and potentially underpowered number of cases that were eligible to be included in the analyses. Anecdotally participants expressed physical discomfort while wearing an accelerometer and it is possible that social stigma and personal embarrassment associated with wearing the device may have impacted wear time compliance. The impact of poor participant compliance on the attrition of valid (i.e., insufficient wear time to meet inclusion criteria) accelerometer data has been noted by other studies (e.g., Webber et al., 2008). Further investigation of strategies to improve accelerometer compliance in adolescents is clearly warranted.

It is also possible that intervention dose was compromised by poor participation rates and fidelity of intervention implementation. For example, we previously reported that intervention delivery fidelity was found to be 74.0% (Lubans et al., 2012). Further, intervention girls attended on average less than half of the total physical activity sessions (42.5%), and attempted only 9.0% of home physical activity and nutrition challenges. Although data shows the parent newsletters (74.5%) and text messages (91.0%) were accessed by most in the intervention group, it is unknown if these were read by participants and parents. In the current study, reasons for poor participation rates and intervention slippage were not documented. Careful monitoring of intervention delivery is needed and qualitative research may help to identify necessary strategies for improving intervention fidelity.

Meanwhile other interventions targeting adolescent girls have experienced similar challenges in their attempts to improve physical activity behaviours. For example, the Stanford and Memphis GEMS studies evaluated community- and home-based obesity prevention programs in pre-adolescent girls living in low-income communities (Klesges et al., 2010; Robinson et al., 2008). Despite their high quality design and implementation, neither study impacted positively on physical activity. Similarly, the school-based New Moves intervention (Neumark-Sztainer et al., 2010) failed to increase adolescent girls' self-reported physical activity, although physical activity stage of change did increase. The TAAG study adopted a socio-ecological framework to reduce the decline in physical activity in adolescent girls, yet intervention effects were only modest (a between-group difference of 1.6 minutes of daily MVPA per day) (Webber et al., 2008). Together, these studies highlight the challenges of working with adolescent girls to reduce the decline in physical activity typically observed in this cohort.

Few studies have examined potential mediators of physical activity in youth interventions (Lubans et al., 2008). A successful school-based intervention in adolescent girls found self-efficacy, perceived benefits and barriers, and commitment to planning to mediate changes in physical activity behaviour (Taymoori & Lubans, 2008). Alternatively, there was no support for the mediating influence of self-efficacy, perceived barriers or enjoyment in the school-based Project-FAB intervention (Dunton et al., 2007), which also targeted adolescent girls. Although strategies used to promote physical activity in the NEAT Girls intervention were carefully developed to target evidence-based social-cognitive and behavioural determinants of activity (Lubans et al., 2008; Salmon et al., 2011), there were no significant treatment effects for any of these outcomes. Our null findings may suggest that the intervention strategies and/or dose received were not sufficient to produce changes in the hypothesised mediators. In addition, it is plausible that the targeted social-cognitive constructs are not effective mediators of behaviour in this specific group. Previous studies examining the mechanisms of physical activity behaviour change in youth interventions have focused almost exclusively on constructs from the SCT, TTM and TPB (Lubans et al., 2008). These theories were developed to explain adult health behaviours and emphasise the individual-level (e.g., self-efficacy, intention) determinants of behaviour. While consistent evidence for the most effective mediators of behaviour in youth have not emerged from these models, future studies may be encouraged to examine alternative mechanisms derived from integrated and socio-ecological models (Rhodes & Nigg, 2011). Socio-ecological models of health behaviour provide guiding frameworks for intervention strategies that target variables beyond the individual level by addressing potential environmental and policy influences. Clearly, continued efforts are needed for theoretically guided interventions that will help develop a stronger evidence base for mediators of behaviour change in adolescent populations. Regardless of the null findings presented here, the importance of reporting no detection of mediating effects has been stressed in the literature (Cerin et al., 2009). This is because published evidence for null findings helps to obtain an unbiased picture of effective theoretical frameworks and strategies for behaviour change in youth.

There are several strengths of the NEAT Girls study that should be noted. These include the use of a group RCT, our monitoring of intervention fidelity, the 12-month study

period, the at-risk study sample, high retention rate at post-test (83%) and use of an objective measure of physical activity. However, there are limitations that should also be noted. A large percentage of participants did not attend weekly program sessions, nor complete weekly challenges. This may have reduced the intensity of the intervention as originally intended. Significant effects reported here for sedentary behaviours were from a self-report measure, suggesting the possibility of response bias due to post-intervention social desirability. The absence of any statistically significant findings for sedentary behaviour or physical activity measured by accelerometry may have been impacted by poor participant compliance resulting in a sample size that was underpowered for these analyses. While assessors were blinded at baseline, this was not the case when 12-month assessments were conducted. Finally, due to concerns for participant burden, potential mediators of sedentary behaviour (e.g., parental screen time rules) were not assessed.

8.5 Conclusion

A school-based intervention tailored for female adolescents of low-SEP significantly reduced time spent in self-reported (but not objectively measured) sedentary activities. However, improvements in physical activity and hypothesised mediators of physical activity behaviour were not observed. Future studies are encouraged to explore alternative mechanisms of behaviour change derived from integrated and socio-ecological theories.

Chapter 9: Two-year Outcomes of the NEAT Girls Obesity Prevention Intervention

Dewar, D. L., Morgan, P. J., Plotnikoff, R. C., Okely, A. D., Collins, C. E., Batterham, M., Callister, R. & Lubans, D. R. (2013). Two-year outcomes from the NEAT Girls obesity prevention cluster randomized controlled trial. *American Journal of Preventive Medicine*, 45(3), 313-317 [Short report].

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Major Findings

This paper reports the 24-month follow-up of primary outcomes, and summary variables for secondary outcomes for the NEAT Girls intervention. After 24-months, favourable and statistically significant intervention effects were reported for changes in percentage body fat (−2.0; 95% CI, −3.0 to −0.9). Positive but non-significant effects were reported for changes in BMI (−0.33 kg/m²; 95% CI, −0.97 to 0.28) and BMI z-score (−0.12; 95% CI, −0.27 to 0.04). Large positive changes were found for screen time (−28 minutes/day; 95% CI −67 to 11), however this finding was not statistically significant. No statistically significant intervention effects were found for the physical activity (accelerometer CPM, MVPA minutes/day), dietary (kcal/kg/day), sedentary behaviour (screen time minutes/day) or self-esteem outcomes.

9.1 Introduction

Both the negative consequences of unhealthy weight gain (Tsiros, Coates, Howe, Grimshaw & Buckley, 2011), and the high likelihood of paediatric obesity tracking from childhood to adulthood (Singh et al., 2008) highlight the importance of targeting youth who are ‘at risk’ of obesity. While there is evidence to support the beneficial effects of school-based child obesity prevention interventions, few studies have assessed maintenance or sustainability of impact after the initial post-test assessments (Waters et al., 2011).

This paper presents the 24-month outcomes from the NEAT Girls intervention. NEAT Girls was a 12-month obesity prevention program targeting adolescent girls of low-SEP (Lubans, Morgan, Dewar et al., 2010). After 12-months, the intervention’s effect on body composition were not significant, but there was a significant group-by-time interaction for reduced screen time (Lubans et al., 2012). The aim of this paper is to report the sustained impact (12-month follow-up) of the program on body composition and health behaviours.

9.2 Methods

9.2.1 Study Design and Participants

The study design, methods and participant characteristics at baseline are reported in detail elsewhere (Lubans, Morgan, Dewar et al., 2010). Briefly, the NEAT Girls intervention was evaluated using a group RCT, which involved 12 secondary schools located in low-income communities in NSW, Australia. Study participants were adolescent girls in Grade 8 at the time of recruitment. Ethics approval for the study was obtained from the University of Newcastle, Australia and the NSW Department of Education and Training Human Research Ethics Committees. School Principals, parents and study participants provided written informed consent.

The sample size calculation was based on change in BMI. To detect a between-group difference of one BMI unit (Robinson et al., 2008), 30 participants from each of the 12 schools were required. This calculation was based on an alpha of 0.05 (two tailed),

power of 80% and a dropout rate of 20%. Baseline assessments were carried out before randomisation during May/June, 2010 (see Figure 9.1). The 12-month (immediate post-program) assessments were completed during May/June in 2011 and these outcomes have been reported previously (Dewar et al., in press; Lubans et al., 2012). This paper reports the 24-month outcomes (May/June, 2012).

9.2.2 Intervention

The intervention was guided by SCT (Bandura, 1986) and informed by the Program X pilot study (Lubans, Morgan, Callister et al., 2009; Lubans, Morgan, Callister et al., 2010). NEAT Girls combined a range of strategies to promote lifestyle (e.g., walking to school) and lifetime physical activity (e.g., resistance training), improve dietary intake and reduce sedentary behaviours. Intervention components included enhanced school sport sessions, lunchtime physical activity sessions, nutrition workshops, interactive educational seminars, pedometers for self-monitoring, student handbooks, parent newsletters, and text messages to reinforce and encourage targeted health behaviours.

9.2.3 Outcome Measures

Data were collected at the study schools by trained RAs. Group allocation to control or intervention treatment did not take place until after baseline assessments were conducted.

Body composition. The primary outcome was BMI (weight [kg]/height [m]²). A portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) and a stadiometer (Model no. PE087, Mentone Educational Centre, Australia) were used to measure weight and height and BMI z-scores were calculated (Cole et al., 2000). The Imp™ SFB7 bioelectrical impedance analyser examined percentage body fat (Lubans, Morgan, Callister et al., 2011).

Physical activity. ActiGraph accelerometers (MTI models 7164, GT1M, GT3X) were used to collect physical activity data. Participants' data were included in the analyses if accelerometers were worn for ≥ 600 minutes per day for at least three days, including at least one weekend day. The data were collected in 30-second epochs and activity

thresholds (Trost et al., 2011) were used to calculate time spent in MPA (1148–2005 counts) and VPA (≥ 2006 counts). Mean CPM and percentage of time in MVPA were calculated.

Dietary Intake. Dietary intake was assessed using the Australian Child and Adolescent Eating Survey (version 1.2) (Watson et al., 2009). Values for total kilojoules/day and total kilojoules/kilogram/day were reported.

Sedentary Behaviour. Participants self-reported their screen-based sedentary behaviours using the ASAQ (Hardy, Booth et al., 2007).

9.2.4 Analysis

Analyses followed the intention-to-treat principle and were conducted using linear mixed models (Mallinckrodt et al., 2004). The mixed models were tested using the PROC MIXED statement in SAS V9.1 (SAS Institute Inc Cary NC) and were adjusted for clustering at the school level. All statistical tests were two tailed and p -values were adjusted for multiple computations (critical p -value = 0.0063).

9.3 Results

The sample included 357 ($M = 13.2$ years, $SD = 0.5$) girls and at baseline, 27.9% and 16.2% of the sample were overweight or obese, respectively. At the 24-month assessments, 114 (64.0%) and 123 (68.7%) girls were retained in the intervention and control groups respectively (see Figure 9.1). Changes in BMI were not statistically significant (see Table 9.1), but there was a statistically significant group-by-time interaction effect for percentage body fat (-2.0% , $p = .006$). The intervention group decreased their screen time and both groups decreased their physical activity and total daily energy intake over the 24-month study period. There were no significant group-by-effects for any of the health behaviours.

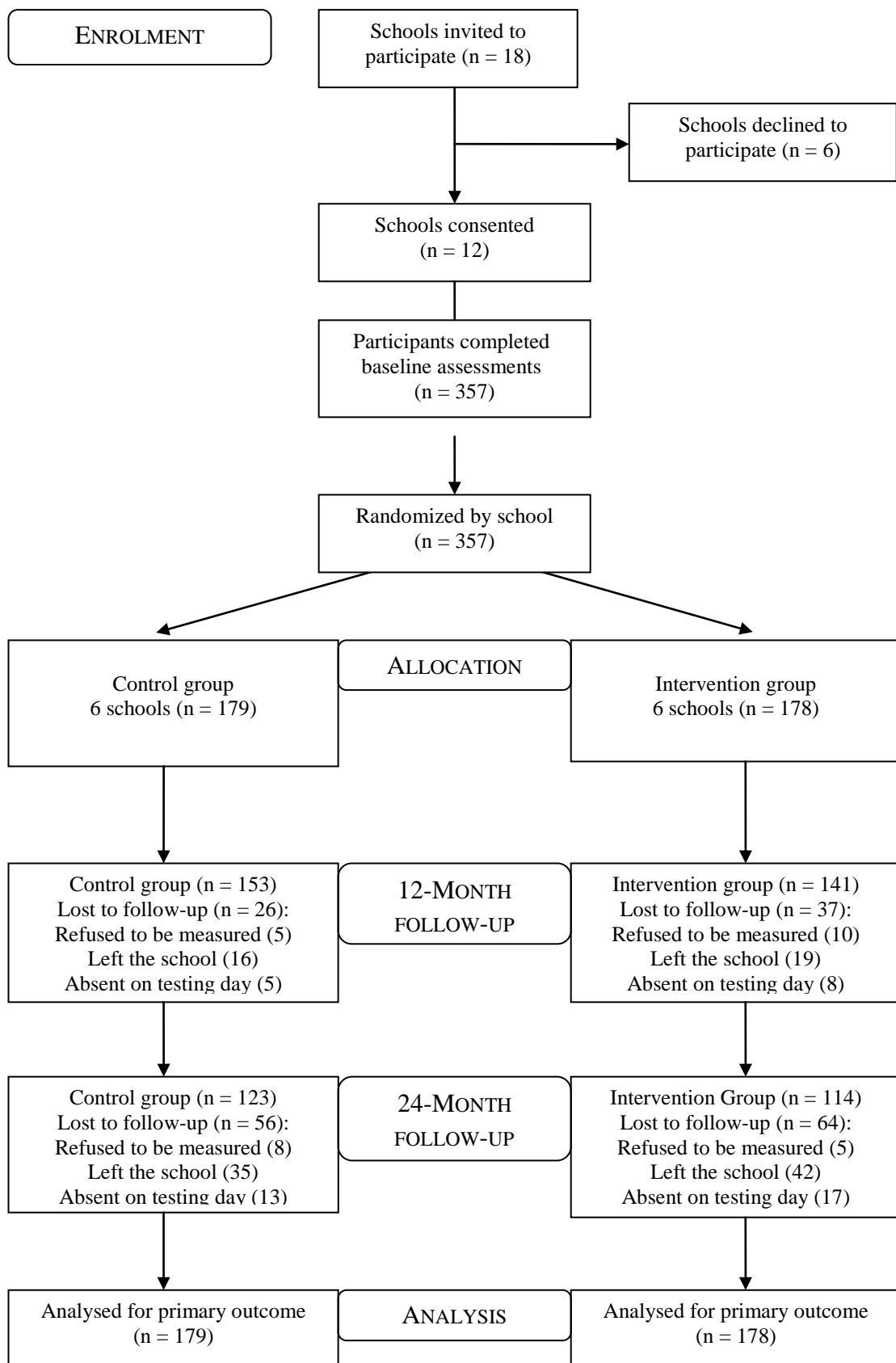


Figure 9.1: Flow of participants through the study

Table 9.1: Changes in outcomes measures and between-group differences

Measure	Baseline, Mean (SD)		12-Month, Mean (SD)		24-Month, Mean (SD)		Adjusted Difference ^a (95% CI)	Group*Time <i>p</i>
	Control (n = 179)	Intervention (n = 178)	Control (n = 153)	Intervention (n = 141)	Control (n = 121)	Intervention (n = 113)		
BMI (kg/m ²)	22.59 (4.49)	22.70 (4.70)	23.37 (4.68)	23.30 (4.71)	24.11 (5.07)	23.86 (4.77)	−0.33 (−0.97 to 0.28)	0.353
BMI z-score	0.78 (1.16)	0.82 (1.12)	0.81 (1.17)	0.76 (1.16)	0.82 (1.20)	0.74 (1.18)	−0.12 (−0.27 to 0.04)	0.178
Body fat (%)	28.3 (6.8)	29.6 (6.5)	32.6 (5.9)	32.7 (5.8)	30.1 (6.4)	29.3 (6.7)	−2.0 (−3.0 to −0.9)	0.006
Accelerometer (counts/min ^{bc})	391.6 (320.3 to 478.2)	413.3 (323.6 to 502.8)	368.9 (284.2 to 458.7)	298.3 (242.1 to 391.3)	350.0 (287.6 to 409.7)	323.4 (173.3 to 378.7)	−40.0 (−96.1 to 16.3)	0.160
Per cent MVPA (%) ^{bc}	4.50 (4.30 to 5.70)	4.90 (3.40 to 6.20)	4.05 (2.73 to 5.90)	3.50 (2.35 to 5.00)	4.14 (2.62 to 5.64)	3.31 (2.28 to 5.00)	−0.77 (−1.84 to 0.29)	0.257
Screen time daily (min/day) ^b	220.7 (162.7 to 341.8)	240.0 (161.8 to 368.6)	248.6 (177.9 to 355.7)	231.4 (161.8 to 375.4)	207.1 (117.3 to 306.9)	200.0 (127.5 to 286.1)	−28.3 (−67 to 11)	0.159
Energy intake (kcal/day) ^b	2241.2 (1259.8)	2598.8 (1763.6)	2233.8 (1551.9)	2524.8 (1610.0)	2072.1 (1889.1 to 2255.5)	2045.2 (1852.1 to 2238.1)	−86.4 (−368.3 to 195.7)	0.291
Adjusted energy intake (kcal/kg/day) ^b	36.7 (106.4 to 214.2)	35.6 (110.4 to 222.3)	33.1 (93.9 to 193.6)	35.7 (98.4 to 226.5)	33.6 (29.8 to 37.3)	33.8 (30.0 to 37.9)	−0.5 (−5.7 to 5.0)	0.393

Note: Abbreviations: BMI, body mass index; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; ^aAdjusted mean difference and 95% CI between NEAT Girls and control groups after 24-months (Intervention minus control); ^bData were transformed owing to non-normality and median and interquartile range provided; ^c221, 88 and 84 participants wore accelerometers for ≥600 minutes on ≥3 days including a weekend day at baseline, 12- and 24- months respectively.

9.4 Discussion

This paper reports the sustained impact of the NEAT Girls intervention on body composition and health behaviours. After 24-months, the NEAT Girls intervention effect on the primary outcome (BMI) was not significant, but there was a significant between-group difference of 2% body fat in favour of the intervention group. A difference of this magnitude may be considered clinically significant. Evidence from recent longitudinal (Dai et al., 2009) and experimental (Foster et al., 2010) studies have demonstrated that similar changes in body composition are associated with more favourable cholesterol and fasting insulin levels in youth.

The absence of a statistically significant intervention effect on BMI and BMI z-score, despite significant improvements in body fatness is consistent with findings from previous obesity prevention studies in adolescents, (McMurray et al., 2002; Singh et al., 2009) and highlight the challenges of accurately assessing body composition in youth. Currently, there is no consensus regarding the most appropriate measure for assessing change in obesity prevention studies. Cole and colleagues (2005) suggest BMI is the best measure of adiposity change in growing youth. Yet others have argued that BMI lacks the sensitivity to distinguish between fat and FFM, and that alternate measures (e.g., skinfolds) are more suitable for detecting change in body composition (McMurray et al., 2002; Singh et al., 2009).

After 24-months, there were no significant intervention effects for any of the behavioural outcomes. Although there was a significant between-group difference of 30 minutes screen time at the 12-month assessments (Lubans et al., 2012), this difference was no longer significant at 24-months.. It appears that the NEAT Girls intervention had a more favourable effect on sedentary behaviour than physical activity or dietary behaviours. Interestingly, these results support findings from a review of behavioural interventions to prevent obesity in youth, which indicated that strategies to reduce unhealthy behaviours seem to be more effective than strategies to increase healthy behaviours (Kamath et al., 2008).

The study strengths include the group RCT design, the unique study population and monitoring of intervention fidelity. Further, the inclusion of 24-month assessments provides evidence for the distal impact of the 12-month intervention. However, there are some limitations that should be noted, including the use of self-report measures to assess changes in screen time and dietary behaviours, and poor accelerometer compliance. Finally, due to participant attrition, the analyses were underpowered to detect small changes in BMI. This combined with lack of measurement precision may have prevented us from detecting relatively large intervention effects in behavioural outcomes.

9.5 Conclusion

The NEAT Girls intervention resulted in statistically significant improvements in body fatness that may have clinical importance. Reductions in screen time were also observed over the study period that may have important implications for preventing unhealthy weight gain among adolescent girls living in low-income communities. The current findings demonstrate the potential for multi-component school-based interventions, but also highlight the need to identify strategies for retaining participants in obesity prevention interventions, especially those from disadvantaged communities.

Chapter 10: Discussion and Recommendations for Future Research and Practice

10.1 Overview

This chapter summarises the key findings from the three main inter-related studies presented in this thesis:

- Section 10.2.1: development and psychometric evaluation of two social-cognitive measures related to adolescent dietary and physical activity behaviour,
- Section 10.2.2: a test of SCT to explain change in physical activity behaviour in adolescent girls of low-SEP,
- Section 10.2.3: evaluation of a school-based obesity prevention program for adolescent girls of low-SEP.

For each section, key findings, research strengths, limitations and recommendations for future research and practice are provided.

10.2 Summary of Findings, Discussion and Implications

10.2.1 Development and Psychometric Evaluation of Two Social-cognitive Measures Related to Adolescent Dietary and Physical Activity Behaviour

10.2.1.1 Findings and Discussion

The aim of this study was to develop and evaluate two comprehensive questionnaires, each measuring several social-cognitive variables related to dietary and physical activity behaviour in adolescents. Many existing instruments have been criticised for their weak psychometric properties (Brown et al., 2009; Cerin et al., 2009). Further, many earlier measures comprised a large number of items (e.g., Jago et al., 2009; Perry et al., 2008; Robertson-Wilson et al., 2007), which may be problematic given the high respondent burden, particularly when researchers are interested in *several* social-

cognitive measures of dietary and physical activity behaviour. Hence, more parsimonious solutions are needed.

The current scales were examined independently for a variety of reliability properties and construct validity. Results demonstrated each measure represented good-to-excellent internal consistency reliability (Cronbach's $\alpha = 0.81$ to 0.91) and test-retest repeatability (ICC = 0.63 to 0.79). CFA showed each model was an acceptable-to-exact fit to the data, and that the majority of items loaded adequately on their latent construct.

Comparing these findings with previous evaluations of theoretical measures of dietary and physical activity behaviour is difficult. For example, the current measures were developed to reflect a generalised set of 'healthy eating' behaviours that are based on current dietary guidelines for adolescents. Previous theoretical measures of dietary behaviour have focused on only one specific dietary aspect (e.g., Reynolds et al., 2002; Rossi et al., 2001). For example, social-cognitive measures (self-efficacy, outcome expectations and family support), specifically related to fruit and vegetable intake were evaluated in a sample of African-American pre-adolescent girls (Sherrill-Mittleman et al., 2009). These measures reported poor-to-good internal consistency reliability ($\alpha = 0.53$ to 0.85), while only a few of the measures demonstrated concurrent validity showing small yet significant correlations with dietary outcomes [i.e., self-efficacy for total daily fat intake ($r = -0.16$) and energy intake ($r = -0.17$)].

Alternatively, other measures are based on different theories and thus different theoretical constructs. For example, Backman et al. (2002) developed psychosocial measures related to 'healthful dietary behaviour' in adolescents that were based on constructs from the TPB (e.g., intention, attitude, subjective norm and perceived behavioural control). Each measure demonstrated acceptable internal consistency ($\alpha = 0.73$ to 0.87). While content validity was verified by experts, other forms of validity and reliability were not reported.

Clearly, comparison of findings is also challenging due to a lack of consistency in the types of psychometric properties tested and reported. The current study reported reliability properties for both internal consistency and test-retest repeatability (ICC).

While there is a tendency for many previously evaluated measures to report internal consistency, a limitation is that ICC values are infrequently reported (e.g., Backman et al., 2002; Sherrill-Mittleman et al., 2009). Both types of reliability are important to establish as they vary somewhat in representation. While internal consistency refers to the degree of interrelatedness among items with a measure, test-retest reliability (ICC) indicates a measure's stability (Thomas et al., 2005).

The types of validity examined and reported for other similar measures also vary. For the current study, establishing the construct validity of each scale involved an examination of the internal factorial structure of each scale. That is, examining how well the items independently and collectively within a scale loaded on the latent construct, which the scale intended to represent. Among other validation studies of theoretical measures, there is a tendency for external forms of validity to be reported, such as convergent or concurrent validity where correlations between the theoretical measures of interest and other previously validated measures (e.g., other theoretical measures or actual measures of behaviour) are examined (e.g., Durant et al., 2009; Sherrill-Mittleman et al., 2009). For example, Durant et al. (2009) evaluated the concurrent validity of measures of perceived environmental and safety barriers to adolescent physical activity in the neighbourhood by examining associations with the frequency of neighbourhood use for physical activity. The authors found perceived barriers were significantly associated with physical activity in boys, but not girls.

Finally, there is a lack of consistency in the model-fit indices reported in the literature (e.g., Dishman et al., 2010; Motl et al., 2000). For example, the current study reported CFI, GFI, AGFI and RMSEA. Alternatively, Dishman et al. (2010) reported CFI, non-normed fit index (NNFI), RMSEA and SRMR to support model fit of social-cognitive measures for adolescent girls' physical activity. Such variation in the literature may indicate reporting bias, where only the stronger fit indices are perhaps presented by researchers to provide evidence for the utility of their measures. Clearly, a set of universally agreed upon standards for examining and reporting model fit is needed to enhance the comparability of validation studies.

10.2.1.2 Research Strengths and Limitations

Few comprehensive physical activity and dietary behaviour questionnaires that include multiple theoretically aligned constructs have been developed and evaluated in adolescent populations. The questionnaires developed for this study provide a parsimonious solution for researchers interested in assessing multiple social-cognitive constructs related to adolescent dietary and physical activity behaviour.

Both questionnaires provide unique features to support their novelty. The questionnaire related to dietary behaviour is the first comprehensive set of social-cognitive measures related to 'healthy eating' based on current dietary recommendations for adolescents (National Health and Medical Research Council, 2003). Considering that many interventions targeting dietary behaviour in youth promote a variety of important dietary behaviours based on dietary guidelines (e.g., Haerens, Deforche, Maes, Cardon et al., 2006; Neumark-Sztainer et al., 2010), the current dietary measures may provide researchers with a practical solution for examining the mechanisms of healthy eating behaviours in adolescents.

Meanwhile, the physical activity questionnaire includes novel items that examine the potential role of modern technology (e.g., iPods, pedometers, mobile phone features) to support adolescents' participation in physical activity. The inclusion of such items provides a more modern set of items for researchers when examining potential influences of physical activity in this population. Further, instrument sensitivity may be improved to detect these influences, especially when modern technological devices have become commonplace for many adolescents today (Australian Communications & Media Authority, 2007; Roy Morgan Research, 2010). This feature has important implications following an increase in the number of physical activity interventions in adolescents that have adopted personal technologies such as pedometers and mobile phones as self-monitoring tools for physical activity (Lubans, Morgan & Tudor-Locke, 2009; Lubans, Morgan, Callister et al., 2009; Newton et al., 2009).

However, there are also some study limitations that should be acknowledged. The sample was relatively homogenous and further testing in diverse populations is needed. Although the sample size was comparable to previous validation studies, a larger

sample may be required to conduct additional analyses (e.g., multi-group analyses in a cross-validation study). Moreover, the validity tests performed are preliminary and to further strengthen the case for the measure's psychometric properties, further evaluations of validity (e.g., concurrent and convergent validity) are encouraged.

10.2.1.3 Implications for Research and Practice

Findings from the current study suggest the social-cognitive scales have acceptable reliability and construct validity. As such, these measures have utility for identifying potential social-cognitive correlates, mediators and determinants of adolescent dietary and physical activity behaviour. Consequently, these scales may be used to strengthen tests of theory to improve our understanding of physical activity and dietary behaviour in adolescents.

10.2.2 A Test of SCT to Explain Change in Physical Activity Behaviour in Adolescent Girls of Low-SEP

10.2.2.1 Findings and Discussion

Physical activity declines precipitously during adolescence, particularly in girls, and adolescent girls of low-SEP are typically less active than those from middle and high socio-economic backgrounds (Brodersen et al., 2007; Nader et al., 2008). For these reasons, there has been considerable interest in improving our understanding of what drives physical activity behaviour in this group to guide intervention efforts. As such, models of social cognition have been adopted by many researchers to help identify what role various psychological and social factors may have in influencing physical activity behaviours in young people (Hagger, 2009). Hence, the aim of this study was to test the capacity of the structural paths of influence proposed in Bandura's SCT model (2004) to explain change in objectively measured physical activity (i.e., daily MVPA minutes) over a 12-month period among adolescent girls of low-SEP. To the authors' knowledge, this was the first study to examine the predictive power of SCT to explain objectively measured physical activity change in this group.

Based on SCT, it was hypothesised that self-efficacy, outcome expectations and intention (proximal goals) for physical activity would directly predict change in MVPA

(daily minutes), while outcome expectations, intention, and facilitators to physical activity participation would mediate the relationship between self-efficacy and change in MVPA.

The SCT constructs explained 28% of the variance in behaviour change, and 34% of the variance in intention. The model-fit indices indicated the data were a good fit to the model, however only self-efficacy was found to directly predict change in physical activity. Intention and outcome expectations did not predict behaviour as hypothesised. Together, these findings suggest the model may require further refinement to accurately explain and predict physical activity behaviour change in adolescent girls of low-SEP.

In short, these findings demonstrate much of the variance for physical activity and intention remains unexplained by the proposed model. These findings are consistent with a recent meta-analysis of social-cognitive theories to explain physical activity behaviour in adolescents that revealed the variance explained for physical activity (33%) and intention (48%) was moderate (Plotnikoff et al., 2013).

The current model tested also failed to establish significant pathways between most of the social-cognitive variables and behaviour change. Only self-efficacy predicted change in physical activity. Consistent support for self-efficacy's role as a determinant and mediator of physical activity behaviour in adolescents has emerged in the literature (Beets et al., 2007; Martin et al., 2011; Taymoori & Lubans, 2008; Taymoori, Rhodes et al., 2010). Collectively, these findings suggest strategies to increase adolescents' self-efficacy for physical activity are important and should be targeted in future interventions.

Meanwhile, intention did not predict behaviour change as hypothesised. Indeed, intention-behaviour discordance has been consistently identified in the physical activity domain. For example, Rhodes and Dickau's (2012) recent meta-analysis of experimental evidence demonstrated the intention-behaviour association to be weak and not meaningful. Attempts to close the intention-behaviour gap have been addressed in the literature, which may give direction for future research in this field. For instance, there have been calls to improve the measurement of intention, as it has been common practice to measure using a single item, which may not be sufficient to assess the

concept as originally defined (Ajzen, 1991; Rhodes & Dickau, 2013). There is also some evidence to suggest that intention may not be the direct antecedent of physical activity as originally theorised, but rather mediated by other variables such as self-efficacy (Sniehotta, 2009). Moderating mechanisms have also been explored to help identify which factors impede or facilitate the translation of intentions into behaviour. For instance, in their recent review, Rhodes and Dickau (2013) found intention stability, anticipated regret, conscientiousness, self-efficacy, planning, extraversion, habit and environmental proximity to recreation showed evidence for moderation.

Similar to intentions, the current study showed outcome expectations were not associated with behaviour change. The notion that the outcomes expected for physical activity behaviour may indirectly, rather than directly, predict behaviour as originally proposed by the current study has been supported in some studies. For example, following an online physical activity and dietary intervention, Anderson-Bill and colleagues (2011) found outcome expectations had an indirect positive effect on physical activity through modification of self-regulatory behaviours.

Together these findings suggest that augmented and integrated models of health behaviour theory may be necessary to accurately explain physical activity in behaviour in adolescents. In their recent paper, Rhodes and Nigg (2011) discussed the importance of augmenting theoretical models with additional physical activity constructs to improve the explanatory capacity of models. For example, in a recent cross-sectional test of the SCT model in adolescent girls, Lubans and colleagues (2011) added physical self-concept to the hypothesised model as a direct and indirect predictor of objectively measured physical activity through physical activity behavioural strategies and outcome expectations. The authors based their decision on existing evidence for the importance of physical self-concept in predicting physical activity in adolescent girls (Crocker et al., 2006). Physical self-concept was significantly associated with behaviour, yet the model explained only a small portion of the variance in behaviour (5%), suggesting further refinement of the theoretical model.

The case for theory augmentation is further strengthened by Rhodes and Nigg (2011) who suggest that the application of existing theories to explain physical activity behaviour may be insufficient because physical activity psychology is indeed its own

discipline. Behavioural theories used in physical activity research to date have originated from other parent disciplines such as social psychology, epidemiology and sociology (Biddle & Nigg, 2000). Meanwhile, it is obvious that physical activity sets itself apart from other health behaviours—for example, it is an adoption behaviour (versus cessation behaviour), it is not a necessary behaviour (versus eating), and is not a short-term once only decision (versus vaccinations) (Rhodes & Nigg, 2011).

Based on these observations, it seems justified that unique and perhaps, integrated theories of physical activity should be pursued. Indeed, exploring combined models of social cognition with other ecological components may be warranted (Hagger, 2009; Plotnikoff et al., 2013). Hagger (2009) discusses the integration of theoretical models by combining constructs, for which there has been prior support for their influence on physical activity, from across two or more theories to develop unique models of behaviour. Indeed, Hagger & Chatzisarantis (2009) demonstrated some support for integrated theory during their meta-analysis of studies integrating the TPB and SDT in a variety of health contexts. That is, the explained variance for behaviour (58%) and intention (65%) was considerably larger than findings from another meta-analysis of single theoretical models of social cognition to explain physical activity behaviour in adolescents (33% and 48% respectively) (Plotnikoff et al., 2013).

Comparing the current findings with other research in adolescents is difficult. A recent review of social-cognitive theories to explain physical activity behaviour in adolescents has revealed research in this area is limited (Plotnikoff et al., 2013). The authors found that the TPB was the most commonly tested theory in adolescent groups, and a meta-analysis revealed that much of the variance in physical activity remains unexplained (i.e., only 33%). Further, only three studies had evaluated models based on SCT (Martin et al., 2011; Strauss et al., 2001; Taymoori, Rhodes et al., 2010), yet none of these studies had tested the utility of Bandura's (2004) reconceptualised model in adolescents. Among the studies reviewed, Plotnikoff and colleagues (2013) noted an over-reliance on cross-sectional designs to test theory, which cannot provide evidence for causality (Weinstein, 2007). Hence, the authors highlighted the need for more rigorous and applied theory tests that involve longitudinal and experimental study designs. Plotnikoff et al. (2013) also found an over-reliance on self-report measures of physical activity, which have been criticised for their questionable accuracy due to response bias and the

difficulty young people may have in recalling past behaviour (Sallis & Saelens, 2000). Thus, future studies were encouraged to include an objective measure of physical activity behaviour, which was a method employed by the current study.

10.2.2.2 Research Strengths and Limitations

Many previous studies in this field have relied on cross-sectional designs and self-report measures of physical activity (e.g., Martin et al., 2011; Taymoori, Lubans & Berry, 2010; Taymoori, Rhodes et al., 2010). To our knowledge, this is the first longitudinal study to examine the utility of SCT to explain change in objectively measured physical activity in adolescent girls of low-SEP. However, there are some limitations to this study that should be noted. Intention was examined using a single item measure, which may be problematic for precise measurement of the concept. It is also important to note the self-efficacy scale only included items pertaining to barriers-efficacy (i.e., confidence to overcome barriers to physical activity). Finally, owing to the smaller sample size limiting model parameters, parental support was the only factor included as a facilitator to physical activity.

10.2.2.3 Implications for Practice and Future Research

Although the study findings do not provide evidence for the utility of Bandura's (2004) reconceptualised SCT model to explain change in physical activity behaviour in the study sample, self-efficacy was found to directly predict behaviour change. There is growing consensus that physical activity theory needs to evolve to allow knowledge in this field to advance (Cerin et al., 2009; Hagger, 2009; Rhodes & Nigg, 2011). As discussed previously, theory integration and augmentation have been identified as important strategies for advancing health behaviour theory. Such approaches are clearly warranted considering the lack of support for existing theories and the considerable overlap in the content and operationalisation of constructs among multiple theories (Bandura, 2004; Hagger & Chatzisarantis, 2005; Plotnikoff et al., 2013). Augmentation can occur through integration of theoretical models or can add depth to an existing model if new constructs are tested as mediators of others. Hence, this may offer rigour to the original model if these additional constructs are not supported, or strengthen the model if the explained variance in behaviour is improved (Rhodes & Nigg, 2011).

There may also be value in exploring the utility of social-cognitive models that are integrated with ecological components (e.g., individual, interpersonal, community, organisation and policy factors) (Hagger, 2009; Plotnikoff et al., 2013). Recent reviews of physical activity and dietary mediators in youth have highlighted the preoccupation with intrapersonal and interpersonal level constructs (Cerin et al., 2009; Lubans et al., 2008). There is cross-sectional evidence to support the influence of the environment on physical activity behaviour in youth (e.g., policy, environmental and school/community setting influences) (e.g., Ferreira et al., 2007), yet few studies have tested environmental constructs in longitudinal and experimental studies as mediators.

Finally, it is important that future research focusing on health behaviour theory involve experimental and longitudinal study designs. Such approaches are logical considering that behaviour ‘change’ is the central impetus for this line of research. Specifically, testing the application of theory for behaviour change can help to determine if theoretical constructs are adaptable, and if such an adaptation contributes to behaviour change.

10.2.3 Evaluation of a School-based Obesity Prevention Program for Adolescent Girls of Low-SEP

10.2.3.1 Findings and Discussion

The aim of this study was to evaluate the impact of a 12-month obesity prevention program among adolescent girls living in low-income communities. After 24-months, the NEAT Girls intervention resulted in favourable changes in BMI and BMI z-score outcomes, although only changes in percentage body fat were statistically significant (-2.0% [CI, -3.0 to -0.9], $p = .006$). Large but non-significant reductions in daily screen time (-28 minutes [CI, -67 to 11]; $p = .159$) may help to explain the intervention effects on body composition. Changes in physical activity and dietary outcomes, self-esteem and hypothesised mediators of physical activity and dietary behaviour were not detected.

The absence of a statistically significant intervention effect on BMI and BMI z-score, despite significant improvements in body fatness are consistent with findings from

previous obesity prevention studies in adolescents (McMurray et al., 2002; Singh et al., 2009). Together, these findings may highlight the challenges of accurately assessing body composition in youth. Currently, there is no consensus regarding the most appropriate measure for assessing adiposity change in obesity prevention studies. Some literature supports BMI as the best measure in growing youth (Cole et al., 2005), yet others debate this, suggesting that alternate measures are more sensitive to detecting change in fatness and therefore are more suitable (e.g., skinfold, DXA and bioelectrical impedance analysis) (Singh, Chinapaw, Brug & Van Mechelen, 2007; Singh et al., 2009). The improvements in body fat, rather than BMI (in comparison to the control group), may be attributable to increases in lean body mass resulting from resistance training activities that were included in the intervention.

The intervention effects on body fat are important when considering the need for long-term evidence of obesity prevention interventions. These positive findings have both clinical importance and important public health implications. Body fatness is a risk factor for cardiovascular disease and Type 2 Diabetes in youth (Goran et al., 2003), and even modest decreases in body fat percentage have been associated with improvements in markers of these and other chronic diseases in adolescents (Dai et al., 2009; Foster et al., 2010). When considering the high likelihood of paediatric-onset obesity tracking into adulthood, reducing the accumulation of body fat during adolescence may have both short- and long-term benefits.

Despite improvements in body fat after 24-months, there were no accompanying significant between-group changes for any of the behavioural outcomes. The reductions in screen time were similar at 12- and 24- months; however, the findings were only statistically significant at 12-months. Even so, these positive changes in behaviour alone may have important implications for health as there is emerging evidence to suggest that time spent sedentary is positively associated with risk of obesity (Mitchell et al., 2009). Additionally, the adverse health outcomes of sedentary behaviour, including overweight and obesity, are independent of physical activity (Ekeland et al., 2006). For the current study, the improvements in screen time behaviour may have been sufficient to influence the positive changes observed in body fatness necessary for preventing unhealthy weight gain.

There are several possible explanations for the null findings for behavioural outcomes. First, inaccurate measurement of behavioural outcomes and poor compliance to assessment protocols may be contributing factors. Poor accelerometer wear time compliance resulted in a small percentage of the study sample included in the analyses for physical activity data ($n = 224$, 88 and 84 at baseline, 12- and 24- months respectively), and this is a challenge that has also been noted by other adolescent studies (e.g., Brennan et al., 2005). Consequently, this resulted in an underpowered analysis for the current study for which the findings cannot be representative of the overall study sample. A further limitation of accelerometers is that they lack the sensitivity to accurately detect non-ambulatory physical activity. Hence, these devices do not adequately capture all types of activity, and this is a restriction considering that many of the physical activities that the NEAT Girls program promoted (e.g., resistance training) were not ambulatory.

Respondent bias is another potential problem for the self-report measures used for dietary and sedentary behaviour. Both groups reported non-significant decreases in daily screen time and total energy intake, and it is possible this finding will be subject to over-reporting due to post-intervention social desirability. Conversely, it is also possible that the FFQ used to assess dietary outcomes was not sensitive enough to identify between-group differences, considering the complexity of dietary intake and hence capturing dietary behaviours.

Null findings for the behavioural outcomes may also have been compromised by intervention dose due to poor participation rates and program compliance reported for some intervention components. There are a number of potential reasons for poor compliance. Teachers in some of the study schools reported that extra-curricular activities occasionally clashed with the NEAT Girls sessions. In addition, teachers communicated constraint by other school-based responsibilities, which may have impacted adversely on the complete delivery of intervention components. This may suggest that a more intensive intervention would be less feasible in these schools, and that future studies need to find ways in which school-based interventions can be easily and sustainably delivered to maximise impact. Further, an important strategy for future interventions may involve targeting teachers through professional development workshops designed to ensure teachers feel supported in their role to deliver

intervention components. This way, solutions can also be devised with the research team when program strategies are not proving sustainable or effective in individual schools.

Finally, the findings did not support changes in the hypothesised mediators of physical activity and dietary behaviour following the intervention period. Due to null findings for the hypothesised mediators and their related behaviours, mediation analyses were not performed. The null findings may suggest that the intervention strategies and/or dose received were not sufficient to produce changes in the hypothesised mediators. Otherwise, measurement may also have been problematic. While validated measures of hypothesised mediators were used, there is also potential for the scales to lack specificity and sensitivity to detect change. For example, the self-efficacy scales related to dietary behaviour provided a global measure of efficacy beliefs. It may have been more beneficial to include specific measures of efficacy beliefs related to these behaviours (e.g., task, barriers, asking or environmental-change efficacy). Yet, due to concerns of high respondent burden, more detailed specific measures were not used.

Alternatively, *response shift theory* (Sprangers & Schwartz, 1999) may explain the null findings for hypothesised mediators. For example, participants in the intervention group indicated that they were moderately confident in their ability to overcome perceived barriers to physical activity (efficacy beliefs) at baseline, and it is possible that after completing the intervention they recognised the challenges to maintaining these behaviours in the future, which resulted in no improvement in personal efficacy beliefs. It is also possible that participants encountered new barriers relating to these behaviours that subsequently impeded their confidence to be physically active.

Finally, it is also plausible that the targeted social-cognitive constructs are not effective mediators of behaviour in this specific group. Guided by the SCT, the NEAT Girls intervention was designed to target individual and intrapersonal level constructs (e.g., self-efficacy, intention and social support) to improve health behaviours. These theoretical underpinnings alone when operationalised through intervention strategies may not have been sufficient to affect behaviour change. Hence, future studies may be encouraged to examine alternative mechanisms derived from integrated and socio-ecological models (Hagger, 2009; Rhodes & Nigg, 2011).

10.2.3.2 Research Strengths and Limitations

The NEAT Girls study addressed many of the limitations raised in a recent Cochrane review of obesity prevention studies (Waters et al 2011) by using a group RCT design, targeting a high-risk group (i.e., adolescents girls living of low-SEP) and including long-term follow-up of intervention effects (i.e., 24-months). Group RCTs are considered the gold standard for evaluating school-based obesity prevention programs and several procedures were employed to optimise study quality and monitor program implementation. Trained PE teachers and APDs ran components of the program in collaboration with the research team. Data collection personnel were trained to ensure the integrity of the assessment protocol. Program fidelity was assessed by recording the number of sessions delivered in intervention schools, and random observations of program sessions were conducted to determine compliance to program content. Attendance to each session was recorded, and study participants and study teachers in intervention schools completed program satisfaction measures (although not all data for these process evaluations are presented in this thesis).

Adolescent girls of low-SEP have been identified as requiring priority attention for obesity prevention and intervention for energy-balance behaviours. The intervention was designed for the socio-demographic characteristics of the study sample. For example, the physical activity sessions focused on lifetime physical activities that are appealing to adolescent girls at no financial cost to the school or participants. Lifetime activities cater for a range of abilities, require little organisation and are more likely to contribute to positive and sustainable physical activity habits that will be carried into adulthood (Corbin, 2002; Wechsler, Devereaux, Davis & Collins, 2000). The nutrition workshops involved the preparation of inexpensive healthy snacks and meals. Both the physical activities and nutrition workshops were rated favourably by participants. Where mobile phones were not accessible to receive the supportive text messages, participants were emailed messages via standard issue student email accounts.

The 12-month NEAT Girls intervention included 12- (post-test) and 24-month (follow-up) assessments. A common criticism of obesity prevention programs is their short duration (i.e., often ≤ 6 months) and more evidence for the long-term efficacy of

interventions is needed (Waters et al., 2011). Finally, the use of an objective measure of physical activity is a study strength considering that self-report measures have been criticised for their susceptibility to response bias in leading to inaccurate estimates of behaviour (Sallis & Saelens, 2000).

However, there are some limitations that should be noted. Intervention dose may have been compromised by poor adherence among participants for some program components. Significant effects reported here for sedentary behaviours at 12-months were from a self-report measure, suggesting the possibility of response bias due to post-intervention social desirability. Usable data for objective measures of sedentary behaviour and physical activity was also problematic because of poor participant compliance to accelerometer protocol. This resulted in an underpowered sample size for these analyses, which may help to explain the absence of any statistically significant findings for these outcomes. This is further compounded by the inability of accelerometers to detect non-ambulatory physical activity. In addition, dietary intake was assessed using a FFQ, which lacks sensitivity to detect small changes in energy intake and is susceptible to response bias due to self-report. It has been suggested that an interviewer-administered measure of dietary intake (e.g., 24-hour recalls) may improve instrument sensitivity and help to prevent bias due to over- and under-reporting. However, for the current study, the resources, cost and time required to do this were not feasible.

10.2.3.3 Implications for Practice and Future Research

The current findings demonstrate the potential for a multi-component school-based intervention to prevent unfavourable changes in body fatness in adolescent girls of low-SEP. Research into obesity prevention among adolescents is gaining momentum; however, much more work is needed to strengthen the evidence for ‘what works’ in this population. To do this, future research needs to address evidence gaps and the methodological and design weaknesses of earlier studies.

More interventions of longer duration (≥ 12 -months) are needed to determine what strategies are most effective for the long-term maintenance of healthy weight in adolescents. An important part of this process is to improve evaluation designs of

studies so that long-term follow-up of intervention effects are examined. It is also important that future studies include process evaluation that provides information on whether the study was adhered to and conducted as intended. Researchers can then consider the implication of this information on the effectiveness of the intervention.

There is very little evidence for the efficacy of obesity prevention studies in adolescents of low-SEP. More research needs to be conducted in this group to determine what interventions are most effective. In avoiding a 'one-size-fits-all' approach, it may also be necessary for interventions targeting low-SEP groups to differentiate further on the grounds of sex, age and weight status so that the most effective strategies for these individuals can be established. Future, trials should adhere to the criteria outlined in the CONSORT statement and be designed with sufficient power to detect clinically meaningful changes. Qualitative research employed within interventions (e.g., focus groups) will also provide a powerful evidence base on the views of participants and significant others in helping to determine why interventions may be more or less successful.

Clearly, continued efforts are needed for theoretically guided interventions that will help develop a stronger evidence base for mediators of behaviour change in adolescents. While previous studies examining the mechanisms of energy-balance behaviour change in youth interventions have focused almost exclusively on individual and intrapersonal level constructs (e.g., from the SCT, TTM and TPB), future studies may be encouraged to examine alternative mechanisms derived from socio-ecological models such as organisational-, community- and societal-level influences. Alternatively, future research may apply and evaluate integrated theory in behavioural interventions to prevent obesity by examining the role of individual, intrapersonal and ecological factors as potential mechanisms of behaviour change. While socio-ecological theories are becoming more frequently cited in youth obesity prevention trials (e.g., Dziewaltowski et al., 2009; Webber et al., 2008), socio-ecological mechanisms of behaviour change remain largely unexplored. For example, there is strong evidence for school-based interventions with involvement of the family, and thus more interventions targeting adolescents may need to engage a familial component, and examine the role of the family as a mechanism of behaviour change. In short, it is important that researchers examine the impact of the

underlying theory of an intervention to 1) determine the validity of theory to explain behaviour change, and 2) to help inform future research.

10.3 Concluding Remarks

Schools provide an important setting for the delivery of obesity prevention strategies among youth of low-SEP. Schools have regular access to the majority of youth and the necessary provisions in place to support health promotion programs and policies. However, the challenges of working with adolescent girls to improve energy-balance behaviours are evident and continued research is needed to develop, evaluate, refine and disseminate effective programs to prevent obesity in this high-risk population. There is a need to establish the effectiveness of interventions and strategies, not only in relation to their ability to prevent unhealthy weight gain, but also in terms of their reach and potential cost-effectiveness. A challenge for researchers is to find ways in which school-based obesity prevention programs can be delivered easily and resourcefully to ensure their sustainability and maximise their positive effects.

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