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SHORT COMMUNICATION: Objectively measured sedentary behavior, physical activity and plasma lipids in overweight and obese children.

RUNNING HEAD: Sedentariness and plasma lipids in obese children

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ABSTRACT

This study examines the associations between objectively measured sedentary behavior, light (LPA) and moderate-to-vigorous physical activity (MVPA), and plasma lipids in overweight and obese children. Cross-sectional analyses were conducted among 126 children aged 5.5-9.9 years. Sedentary behavior, LPA and MVPA were assessed using accelerometry. Fasting blood samples were analyzed for plasma lipids (high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), and triglycerides (TG)). MVPA was not related to plasma lipids ($P > 0.05$). Independent of age, sex, energy intake, and waist circumference *z*-score, sedentary behavior and LPA were associated with HDL-C ($\beta = -0.23$, 95% CI -0.42 to -0.04, $P = 0.020$; $\beta = 0.20$, 95% CI 0.14 to 0.39, $P = 0.036$, respectively). The strength of the associations remained after additionally adjusting for MVPA (sedentary behavior: $\beta = -0.22$, 95% CI -0.44 to 0.006, $P = 0.056$; LPA: $\beta = 0.19$, 95% CI -0.005 to 0.38, $P = 0.056$, respectively). Substituting at least LPA for sedentary time may contribute to the development of healthy HDL-C levels among overweight and obese children, independent of their adiposity. Comprehensive prevention and treatment strategies to improve plasma HDL-C among overweight and obese children should target reductions in total sedentary time and promote the benefits of LPA, in addition to promoting healthy levels of adiposity, healthy dietary behaviors, and MVPA.

Key words: adiposity, cholesterol, pediatrics, physical activity

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INTRODUCTION

The effects of obesity on metabolic health in childhood are of particular concern for chronic disease prevention (1). Pediatric obesity is associated with an atherogenic dyslipidemia, characterized by increased triglycerides (TG) and decreased high-density lipoprotein cholesterol (HDL-C) (1). Efforts to treat or prevent dyslipidemia complications would benefit from an improved understanding of their etiological and behavioral associations in obese children.

Among adults, sedentary behavior (e.g. sitting) has emerged as a unique risk factor for poor cardio-metabolic health independent of low levels of moderate-to-vigorous physical activity (MVPA) (2-4). However, data among children are limited and predominantly rely on self- or parent-reports of specific types of sedentary behaviors, such as electronic screen time. Population studies that have used an objective measure of sedentary behavior indicate that total sedentary time is associated with insulin resistance, hypertriglyceridemia, and clustered metabolic risk in children and adolescents, independent of adiposity (5, 6). Despite overweight and obese children having an elevated risk of dyslipidemia (1) and low levels of physical activity, associations between objectively measured sedentary behavior, physical activity, and plasma lipids have not yet been investigated in this population. The aim of this study was to examine the associations between objectively measured sedentary behavior, light physical activity (LPA), MVPA, and plasma lipids in overweight and obese children.

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METHODS AND PROCEDURES

Overweight/obese children were recruited into the Hunter Illawarra Kids Challenge Using Parent Support (HIKCUPS) trial (U.S. National Centre for Clinical Trials Registry - NCT00107692)(7), from communities surrounding the Universities of Wollongong and Newcastle, New South Wales, Australia. Baseline data collected from April 2005 to April 2006 were used for the current analyses. Eligibility criteria have been reported in detail elsewhere (7), and included the child being overweight or obese (8), aged 5.5-9.9 years, pre-pubertal (Tanner Stage I) and generally healthy. Of the 165 recruited participants, 126 had complete data for the current analyses. Missing data were random with respect to age, sex, BMI *z*-score and waist circumference *z*-score. Written informed consent was obtained from each child's parent or caregiver, as well as child assent. The Human Research Ethics Committees at both sites approved the study protocol.

Sedentary Behavior and Physical Activity

Habitual sedentary behavior and physical activity were objectively measured using the Actigraph 7164 uniaxial accelerometer (Actigraph, Fort Walton Beach, FL, USA). Participants wore the accelerometer on their right hip during waking hours for 8 consecutive days (excluding aquatic activities) (9). Accelerometers recorded activity counts at 60-sec epochs. Strings of ≥20 consecutive minutes of '0' counts were considered non-wear time and were removed during data reduction. Participant data were included in analyses if accelerometers were worn for ≥600 min.d^{-1} on ≥3 days (76% and 94% had ≥7 and ≥5 days of valid data, respectively). Data were categorized into minutes of sedentary behavior, LPA or MVPA using child-specific cut-points shown to be the most accurate in this age group (10) - sedentary behavior: <100

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counts per minute (cpm); LPA: 100-2295 cpm; and MVPA: ≥2296 cpm. Outcomes were expressed as a percentage of total monitored time.

Sedentary behaviors typically involve sitting, and include watching television, using a computer, completing school work, reading, and sedentary transport. MVPA includes all activities greater than the intensity of a brisk walk (12), such as playing sports, chasing games, or dancing. For children, LPA generally do not involve sitting but are lower in intensity than a brisk walk, and could include walking to school or the shops, standing and playing active computer games, or doing household chores. Children's activity patterns are intermittent, meaning that some 'active' recreational games are characterized by short bursts of MVPA interspersed with periods of LPA or sedentary time.

Plasma Lipids

Blood was collected after children had fasted overnight and was analyzed for HDL-C, low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), and TG at a single accredited pathology service (National Association of Testing Authorities, Australia, accredited) (7, 11).

Confounding variables

Waist circumference, height, and weight were measured, and waist circumference and BMI *z*-scores were calculated using standardized procedures (7, 11). Total daily energy intake ($kJ.kg^{-1}$) and diet quality were calculated from parent-reports using a validated food frequency questionnaire (12). Diet quality included 72 different food items from all five food groups and was calculated from the frequency of response categories where the food was consumed more than once per week.

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Statistical analyses

Plasma lipid outcomes were logarithmically transformed to normalize skewed distributions. Differences in descriptive characteristics by sex were analyzed using independent samples *t*-tests or Mann Whitney *U*-tests. Multivariate linear regression analyses were used to examine the relationships between sedentary behavior, LPA, MVPA, and plasma lipids. Initial models included the following potential confounders: age, sex, adiposity (waist circumference z-score or BMI z-score) and diet (energy intake or diet quality). Subsequent models were also adjusted for MVPA, where sedentary behavior or LPA were the predictor variables. For all models, interactions between age, sex, or weight status (overweight vs. obese) and sedentary behavior, light PA or MVPA were examined but were not significant (p>0.1). Analyses were conducted using PASW version 18.0 (SPSS Inc, Chicago, IL).

RESULTS

Median plasma lipid values for the participating 126 overweight/obese children are reported in Table 1. Boys had a larger waist circumference *z*-score than girls (3.4 s.d. vs. 2.8 s.d., p=0.002) and spent a greater percentage of time in MVPA (8.0% vs. 6.9%, p=0.03). Of the mean 12.6 h.d^{-1} monitored, participants spent 290 (±58) min.d^{-1} sedentary, 413 (±50) min.d^{-1} in LPA, and 53 (±20) min.d^{-1} in MVPA. Forty-seven participants (37%) averaged ≥60 min.d^{-1} in MVPA, and 66 (52%) had low HDL-C (15). Independent of confounders, sedentary behavior was inversely associated and LPA was positively associated with HDL-C, but MVPA was not (Table 1). The findings were consistent when BMI *z*-score was entered for adiposity, or when diet quality was entered for diet (data not shown). After additional adjustment for MVPA,

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the standardized β coefficients remained virtually unchanged, although the confidence intervals widened and the associations approached significance (Table 1). Sedentary behavior, LPA and MVPA were not related to other lipid outcomes.

< insert Table 1 approximately here >

DISCUSSION

To our knowledge this is the first study to demonstrate that objectively measured sedentary behavior and LPA are associated with fasting plasma HDL-C in overweight and obese children. These associations were independent of adiposity and diet, and were stronger than the association between MVPA and HDL-C.

The potentially deleterious association between excessive sedentariness and metabolic outcomes has only recently been investigated using objective measures among children and youth. Independent of adiposity and other confounders, objectively measured total sedentary time is associated with insulin resistance among 9-10-year-old children (5), and to hypertriglyceridemia and clustered metabolic risk in children and adolescents (6). Sedentary behaviors are characterized by the prolonged unloading of the large muscle groups in the legs, back and trunk (3). The corresponding lack of muscle stimulation appears to suppress lipoprotein lipase activity (3, 14) – an enzyme responsible for controlling HDL-C and other metabolic risk factors.

Given the established cardiovascular health benefits of MVPA for children, our null findings for MVPA seem counter-intuitive. However, they are consistent with results

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from the European Youth Heart Study (n = 1732) (6). Apart from a weak but significant association between moderate physical activity and TG, objectively measured physical activity was not associated with plasma lipids. This may indicate that the association between MVPA and plasma lipids in children is weaker than is commonly thought, or it may be due to difficulties in accurately measuring children's physical activity, which is highly variable (15).

Our findings highlight the need for treatment and prevention strategies targeting lipid complications in overweight/obese children to encourage reductions in total sedentary time. However, this time may not necessarily need to be substituted for MVPA to improve health. Although the target of 60 $min.d^{-1}$ of MVPA is an evidence-based guideline that overweight/obese children should be encouraged to meet, it represents only ~5%-8% of their waking hours. The remaining >90% of children's day is spent either sedentary or in LPA, and our results suggest that exchanging some sedentary time for LPA might positively influence HDL-C. Practical examples of this could include swapping some: i) sedentary transport for supervised active transport, ii) screen time for outdoor play, or iii) sedentary computer time for more active computer games. As our sample was of a modest size and included only treatment-seeking overweight and obese children, further research is needed in larger population samples. These cross-sectional findings require confirmation in longitudinal and experimental studies to examine if changes in objectively measured total sedentary time are predictive of changes in HDL-C or other biomarkers, independent of confounders including adiposity and MVPA.

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This study provides preliminary evidence that higher total time in sedentary behavior and lower total time in LPA is associated with lower levels of plasma HDL-C in overweight/obese children, independent of adiposity. Substituting at least LPA for sedentary time may contribute to the development of healthy HDL-C levels among overweight/obese children. Comprehensive prevention and treatment strategies to improve plasma HDL-C among overweight/obese children should target reductions in total sedentary time and promote the benefits of LPA, in addition to the promotion of healthy levels of adiposity, healthy dietary behaviors and MVPA.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Table 1

Standardized regression coefficients for the associations between objectively measured sedentary behavior, light physical activity, moderate-to-vigorous physical activity, and plasma lipids (log mmol/L) in overweight and obese children (n = 126 [a]).

		Sedentary Behavior		Light PA		MVPA	
	Median (IQ range)	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
HDL cholesterol (mmol/L)[b]	1.3 (1.1-1.4)	-0.23 (-0.42 to -0.04)	0.020	0.20 (0.14 to 0.39)	0.036	0.12 (-0.06 to 0.31)	0.187
HDL cholesterol (mmol/L)[c]	-	-0.22 (-0.44 to 0.006)	0.056	0.19 (-0.005 to 0.38)	0.056	-	-
LDL cholesterol (mmol/L)[b*]	2.5 (2.2-2.9)	0.10 (-0.10 to 0.30)	0.341	-0.11 (-0.31 to 0.09)	0.272	0.01 (-0.19 to 0.20)	0.736
Total cholesterol (mmol/L)[b]	4.3 (3.8-4.7)	0.14 (-0.06 to 0.34)	0.168	-0.13 (-0.33 to 0.07)	0.193	-0.06 (-0.26 to 0.13)	0.506
Triglycerides (mmol/L)[b]	0.9 (0.6-1.2)	0.04 (-0.15 to 0.24)	0.660	-0.06 (-0.25 to 0.13)	0.519	0.03 (-0.15 to 0.22)	0.736

[a] mean age: 8.3 ± 1.1 y, mean BMI: 24.7 ± 3.7 kg.m^{-1}, mean BMI z-score: 2.8 ± 0.7 s.d., mean waist circumference: 76.2 ± 9.4 cm, mean waist circumference z-score: 3.0 ± 0.9 s.d., 75% obese, 60% girls); [b] adjusted for age, sex, waist circumference z-score, and energy intake; [c] Model[a] additionally adjusted for MVPA; [*] n = 124 due to missing data for LDL cholesterol. PA, physical activity; MVPA, moderate-to-vigorous physical activity; IQ range, interquartile range.