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Composition of objectively measured physical activity and sedentary behaviour participation across the school-day among disadvantaged Victorian primary school children and influence of gender and weight status

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Strengths and limitations of this study

- This study has various strengths that centre on the objective examination of the physical activity and sedentary behaviour across the school-day with measured anthropometric indices among disadvantaged primary school children.
- Additionally, this study examines the importance of the before-school, during-school and after-school period for physical activity and sedentary behaviour participation which are commonly examined in isolation, with many studies focussing on the after-school period.
- A limitation of this study is the cross-sectional nature of the data that arises from a sub-sample of possible participants due to the limited number of accelerometers available to the study team.
- Another limitation is the sampling strategy used which deliberately focussed on local government areas with high rates of chronic disease and levels of socioeconomic disadvantage,[1] and thus are not representative of the Victorian population.

Abstract

Background

The after-school period has been described as the 'critical window' for physical activity (PA) participation among school children. However, little is known about the importance of this window when compared to the before and during-school period among socioeconomically disadvantaged children, and influence of gender and weight status.

Methods

Thirty-nine out of 156 (RR= 25%) invited primary schools across 26 local government areas in Victoria, Australia, consented to participate with 856 children (RR= 36%) participating in the wider study. The analysis sample included 298 Grade 4 and Grade 6 children (mean age: 11.2 ± 1.1; 44% male) whom met the minimum accelerometry wear-time criteria and had complete height, weight and health-behaviours questionnaire data. Accelerometry measured duration in daily light-intensity PA (LPA), moderate-to-vigorous PA (MVPA) and sedentary time (ST) was calculated for Before-school = 8-8:59am, During-school = 9am-3:29pm, and After-school = 3:30pm-6pm. Bivariate and multivariate linear regression analyses were conducted.

Results

During-school represented the greatest accumulation of LPA and MVPA compared to the Before and After-school periods. Boys engaged in 102 mins.d^{-1} of LPA (95% CI: 98.5, 104.9) and 62 mins.d^{-1} of MVPA (95% CI: 58.9, 64.7) During-school; girls engaged in 103 mins.d^{-1} of LPA (95% CI: 99.7, 106.5) and 45 mins.d^{-1} of MVPA (95% CI 42.9, 47.4). Linear regression models indicated that girls with overweight or obesity engaged in significantly less LPA, MVPA and more time in ST During-school.

Conclusions

This study highlights the importance of in-school PA compared to after-school PA among socioeconomically disadvantage children whom may have fewer resources to participate in after-school PA.

256/250 abstract word count

Introduction

Regular physical activity (PA) participation has many documented health benefits for children and adolescents.[2 3] Low levels of physical activity (termed physical inactivity) among youths has been associated with negative outcomes including lower high-density lipoprotein cholesterol, hypertension, metabolic syndrome and obesity[2] and increased mental health outcomes (depression, anxiety, self-esteem and cognitive function).[4] Representative self-report data indicate that approximately 80.4% of Australian children and adolescents (aged 5-17 years)[5] engaged in insufficient levels of moderate-to-vigorous physical activity (MVPA) to confer the health benefits (≥ 60mins.d^{-1} of MVPA every day).[6] Together with high levels of sedentary behaviours (SB),[5] which are also linked to negative health,[7] physical inactivity remains a pressing public health concern.

A variety of individual, environmental and psychosocial influences have been associated with PA and SB participation.[8 9] Parallels exist with obesity which is also now accepted to result from a complex array of influences.[10] Single interventions have provided modest changes in child and adolescent PA[11 12] and SB[13 14] leading to a shift in focus to multi-component interventions.[11 12] Schools have become a key setting for single and multiple intervention approaches targeting increasing PA and reduction of SB. The focus on schools is logical due to the sheer volume of time children spend in school and the strong structures (e.g. policy, governance, curriculum, and fiscal) that both influence these environments and are relatively easy to manipulate to try and change PA and SB behaviours. It is acknowledged that schools cannot singularly reverse physical inactivity and SB, but offer great potential in ensuring students achieve the recommended amount MVPA.[11 15]

Efforts to understand the effectiveness of interventions and participation behaviours in schools are hampered by a lack of objective measurement of PA and sedentary behaviour time (ST) across the whole school day.[16] This is emphasised by the limited international literature. Variations in school times and durations appear to be strong determinants of MVPA and ST among school-aged children.[17] A five country European study (Belgium, Greece, Hungary, the Netherlands, Switzerland) among 1,025 children (aged 10-12 years) with valid accelerometry found students spent 4-6% (approx. 13-21 mins-d^{-1}) of the school-day in MVPA and 61-70% (approx. 182-231 mins.d^{-1}) in ST.[17] In addition, a Canadian study among 380 children (aged 8-11 years) found that 14% of and 71% of the school-day was spent in MVPA and ST, respectively, for girls (approx. 53 mins.d^{-1} MVPA and 260 mins.d^{-1} ST) and 17% and 67% for boys (approx. 64 mins.d^{-1} MVPA and 246 mins.d^{-1} ST).[18] To date, it is believed that there is no objective measurement of PA and ST participation across the entire school day (Before, During, After-school) and associations with weight status within the Australian primary school context.

This paper reports on the segmented patterns of PA and ST among Grade 4 and Grade 6 Australian primary school children with valid accelerometry data during Sept-Dec 2013 (Term 4). The paper sets out to answer the following questions:

1. What is the composition of PA and ST before-school, during-school and after-school among predominantly socioeconomically disadvantaged primary school children?
2. What influence does weight status have on the composition of PA and ST across the school-day and does this vary by gender?

Methods

Setting, study population and sampling

This cross-sectional pilot data derives from the Healthy Together Victoria (HTV) and Childhood Obesity study which aims to measure the impacts of HTV on anthropometric and obesogenic behaviours among Victorian children and the environments in which they live. Embedded within HTV is a cluster-randomised control trial of 12 prevention and 12 comparison clusters which were selected through their matched randomisation based on their demographic [Socioeconomic Index for Areas (SEIFA)][19] and chronic disease risk factor prevalence (i.e. unhealthy weight)] of adults within participating LGAs. This study involved the collection of anthropometric and behavioural data among primary and secondary school children from 26 local government areas (LGAs); the details of which have previously been published.[1] In brief, a randomly selected subset of schools from a list of all public and independent primary schools were invited to participate within each LGA. One hundred and fifty-six primary schools were invited during Term 4 (September to December 2013), with 39 schools consenting to participate (school-level response rate (RR) = 25%). Within these schools, all Grade 4 and Grade 6 students were invited (N = 2,357) with 856 parent/guardian consents received through the return of the signed parent/guardian consent form (student-level RR = 36%). In order to examine the segmented patterns of PA and ST, a sub-sample of students who were provided with an accelerometer is utilized in this article (see Appendix 1 for a detailed overview of accelerometry and non-accelerometry participants). Prior to commencing this study ethical approvals from the Victorian Department of Education and Training (2013_002013), the Catholic Archdiocese of Melbourne, Sandhurst, Ballarat and Sale, and Deakin University's Human Research Ethics Committee (2013_095) were sought and granted.

Measures and data management

All participants completed a self-report questionnaire during class (20-35 mins) which collected demographic (date of birth, gender, residential postcode, language spoken at home, country of birth and ancestry), PA and SB participation,[20 21] diet quality[22 23] and perceived health and wellbeing.[24] Participants were also invited to have their height and weight measured by trained research assistants during class time (3-5 mins per student). While the anthropometric measurements were taking place, a random sub-sample were also invited to wear an accelerometer for the proceeding 7-days. The engagement of a sub-sample was necessary due to the limited number of accelerometers; therefore, every second boy and girl in Grade 4 and Grade 6 (e.g. 1st Grade 6 boy and girl, 3rd Grade 6 boy and girl etc.) was invited to wear an accelerometer.

Self-reported residential suburb/postcode was used to categorise individuals within quintiles of Relative Socio-economic Advantage and Disadvantage (IRSAD) which was derived from the Australian Bureau of Statistics (ABS) Socio-Economic Indexes for Areas (SEIFA) index from the 2011 Australian Census.[19] Self-reported language spoken predominantly at home was used to categorise individuals into two categories (English speaking and Language other than English) as a measure of culture and linguistic diversity.[25] The term recognises that groups and individuals differ according to ethnicity, language, race, religion and spirituality and the term CALD is often used to describe groups that differ from the English speaking majority (non-CALD).[25]

Height was measured to the nearest 0.5 cm using a portable stadiometer (Charder HM-200P Portstad, Charder Electronic Co Ltd, Taichung City, Taiwan) and weight to the nearest 0.1 kg using an electronic weight scale (A&D Precision Scale UC-321; A7D Medical, San Jose, CA) without shoes and whilst wearing light clothing. Age and sex-specific body mass index (BMI) z-scores and weight status categories were calculated using the World Health Organization's growth reference.[26]

The ActiGraph GT3X and GT3X+ accelerometer models (ActiGraph, Pensacola, FL) were utilized and participants were instructed to wear the activity monitor on the right hip during waking hours, excluding water based and sparring activities (e.g. boxing). The intergenerational issue of the differing ActiGraph accelerometer models was overcome by selecting a 15-second epoch and 30-hertz sampling rate, which has previously been shown to have strong agreement with total vertical axis counts, total vector magnitude (VM) counts and MVPA among children and adolescents.[27] Nonwear-time was identified by periods in which ≥ 60 minutes of consecutive zero counts were obtained, with a 1-2 minute allowance of counts between 0 and 100.[28] Wear-time was calculated by subtracting nonwear-time from 24 hours. A valid day of wear was considered if ≥ 600 minutes per day (mins.d^{-1}) [28] of wear-time was recorded over a minimum ≥ 3 days; reliable estimates of children's physical activity have been observed with ≥ 600 mins.d^{-1} of monitoring over a minimum of ≥ 2 days.[29] Total vector magnitude (VM) counts per minute (counts.min^{-1}) were calculated to give an indication of overall volume of PA. The VM counts utilise information from three axes via the equation $VM = \sqrt{(Axis\ 1)^2 + (Axis\ 2)^2 + (Axis\ 3)^2}$ and were calculated per epoch of time.[30] Metabolic equivalent units (METs) were assigned to VM counts.min^{-1} to classify the intensity of activity as: sedentary (ST) ≤ 1.5 METs, light (LPA) = 1.5 to 2.9 METs, and moderate-to-vigorous (MVPA) ≥ 3.0 METs[31] using the validated accelerometer cut-points developed by Romanzini et al., (2014).[32] Whilst newer accelerometer models can capture three axes of data,[33] the reporting of this information is less apparent than the singular vertical axis (Axis 1).

Temporal patterns of PA and ST participation during the week were examined using three distinct time-periods that reflected the typical cadence of the school day (Before-school = 8am to 8:59am; During-school = 9am to 3:29pm; and After-school = 3:30pm to 6:00pm). These time-periods were selected to reflect the Australian education environment as well as the time periods commonly used to define the after-school period.[34] Durations spent in sedentary (ST), light (LPA) and moderate-to-vigorous (MVPA) activity within these specific temporal windows were examined as well as durations spent in daily (Mon-Sun) activity. The contribution (proportion) of each of these distinct time-periods to overall ST, LPA and MVPA was calculated by the following formula [100/ Total participation (Mon-Fri) in the respective intensity] X participation in the interested time-period and intensity (Mon-Fri)]. Adherence to the Australian National Physical Activity Guidelines[35] was examined using the averageXdays method,[36] whereby a child is considered compliant if MVPA duration on average exceeds $\geq$ 60 mins.d^{-1} of MVPA.

Statistical analyses

Only participants with complete anthropometric, questionnaire and accelerometry data were included in the analyses (N = 298). No differences were identified in mean age, gender distribution, SEIFA quintile or weight status category between the analysis sample and those not included for analyses (non-participants), although CALD status differed significantly suggesting that proportionally more CALD background were non-participants for various reasons (P$\leq$ 0.001) (Appendix 1). Statistical analyses were conducted using STATA 12.0 (STATA Corp., College Station, Texas, USA). Initial analyses examined whether mean BMI-z score differed between intervention and comparison participants using a multilevel mixed-effects linear regression analysis. No significant difference was detected, supporting the subsequent analyses on combined cross-sectional data.

Independent sample t-tests examined if gender differences were evident as well as differences in weight status category for demographic and behavioural variables. Pearson's Chi-square tests were used to examine differences in proportions. A series of independent linear regression analyses examined the relationship between the dependent variables (MVPA, LPA, ST) and weight status (normal weight and overweight/obesity) During-school, whilst controlling for the potential influences of age, socioeconomic position (SEP), study condition (intervention or comparison) and cluster-based sampling (with LGA utilized as the cluster unit). The regression analyses were stratified by gender since gender is a significant predictor of PA among children[37 38] and separate models were used for MVPA, LPA and ST because sedentary behaviour can be independent of physical activity participation.[39]

Results

Table 1 presents the demographic characteristics of participants with complete accelerometry data by gender and weight status. No significant gender or weight status differences were observed for age, CALD status, SEIFA quintile, accelerometer wear-time, and number of valid weekdays or weekend days of accelerometer monitoring. However, among boys the mean BMI-z score was higher, daily activity counts.min^{-1} and average daily MVPA duration were higher and daily ST was lower compared to girls (all, $P \leq 0.05$). Additionally, girls with overweight/obesity engaged in lower levels of daily LPA, MVPA and higher levels of ST than girls in the normal weight range, which was reflected in the proportion meeting the national physical activity recommendations[35] (all, $P \leq 0.05$). On average, participants spent approximately 8hrs.d^{-1} engaged in ST, 3hrs.d^{-1} in LPA and 1.5hrs.d^{-1} in MVPA regardless of gender or weight status.

Table 1. Descriptive characteristics and unadjusted physical activity and sedentary behaviour patterns of participants (Mean + 95% CI)

		N	Total (Mean ± 95% CI)	N	Normal weight[§] (Mean ± 95% CI)	N	Overweight or Obese (Mean ± 95% CI)
Age (years)							
Boys	(M)	130	11.3 (11.10, 11.48)	82	11.4 (11.18, 11.64)	48	11.1 (10.77, 11.41)
Girls	(F)	168	11.2 (11.01, 11.32)	124	11.1 (10.92, 11.29)	44	11.3 (11.04, 11.64)
Ethnicity- Language							
(Language Other Than English)	(M)	17	13.60%	8	10.26%	9	19.15%
	(F)	21	12.50%	16	12.90%	5	11.36%
SEIFA quintile (%)							
Lowest Quintile	(M)	37	30.33%	25	32.47%	12	26.67%
	(F)	33	20.25%	27	22.13%	6	14.63%
BMI-z	(M)	130	0.6 (0.41, 0.84)	82	-0.1 (-0.31, 0.03)	48	1.9 (1.77, 2.10) ΦΦΦ
	(F)	168	0.3 (0.15, 0.48)*	124	-0.2 (-0.31, -0.04)	44	1.7 (1.51, 1.85) +++
Valid wear (days)							
Valid weekdays	(M)	130	3.9 (3.75, 4.08)	82	3.8 (3.64, 4.05)	48	4.0 (3.76, 4.32)
	(F)	168	3.8 (3.66, 3.97)	124	3.8 (3.64, 4.00)	44	3.8 (3.45, 3.14)
Valid weekend days	(M)	130	1.3 (1.15, 1.43)	82	1.3 (1.17, 1.51)	48	1.2 (0.99, 1.43)
	(F)	168	1.3 (1.17, 1.40)	124	1.3 (1.20, 1.46)	44	1.2 (0.91, 1.40)
Daily wear-time (min.d^{-1})[△]	(M)	130	789.4 (774.99, 803.71)	82	779.7 (763.42, 796.01)	48	805.8 (778.43, 833.19)
(Mon-Sun)	(F)	168	793.3 (780.35, 806.31)	124	792.4 (775.95, 808.86)	44	796.0 (777.46, 814.44)
Daily activity counts (counts.m^{-1})[△] (Mon-Sun)	(M)	130	261.3 (244.28, 278.31)	82	269.1 (247.63, 290.57)	48	248.0 (219.45, 276.48)
	(F)	168	227.8 (214.29; 241.30) **	124	233.8 (217.69,249.85)	44	210 (186.00, 235.90)
Daily Sedentary (min.d^{-1})[△]	(M)	130	479.0 (463.41, 494.57)	82	469.0 (450.72, 487.17)	48	496.1 (467.41, 524.88)
	(F)	168	503.3 (489.37, 517.26) *	124	495.0 (478.00, 511.93)	44	526.9 (503.86, 549.85) +
Daily LPA (min.d^{-1})[△]	(M)	130	192.7 (187.30; 198.12)	82	191.3 (184.13, 198.54)	48	195.1 (186.80, 203.33)
	(F)	168	200.6 (194.96, 206.15)	124	204.6 (198.25, 210.95)	44	189.2 (177.74, 200.57) +

Daily MVPA (min.d^{-1})$^{\triangle}$	(M)	130	116.7 (111.58, 121.84)	82	118.5 (112.03, 124.97)	48	113.7 (105.02, 122.29)
	(F)	168	88.5 (84.37, 92.56) ***	124	91.8 (86.97, 96.60)	44	79.1 (71.73, 86.43) ++
Meeting MVPA guidelines	(M)	126	96.9%	80	97.6%	46	95.8%
(Average Method %)	(F)	144	85.7% **	112	90.3%	32	72.7%++

Independent-sample t-tests or chi-square tests used to determine significant mean or proportional differences between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Boys with normal weight boys differed significantly to boys with overweight/obesity $^{\Phi}$= P≤0.05; $^{\Phi\Phi\Phi}$ = P≤0.001; Girls with normal weight girls differed significantly to girls with overweight/obesity with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); $^{\triangle}$= based on Greater than 600min.d^{-1} of monitoring over => 3 days; and SEIFA = Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD); §= Normal weight category included underweight

Participation in PA and ST across the three specific school-day time-periods (Before-school (8am-9am), During-school (9am-3:30pm) and After-school (3:30-6pm) are presented in Figures 1a-1c by gender and weight status. Bivariate analyses revealed no significant differences between boys in the normal weight range and those in the overweight/obese range within the Before-school, During-school or After-school period for average activity counts, LPA, MVPA or ST duration. In contrast, among girls, significant differences were evident between the weight status categories within the During-school period. Those with overweight/obesity had significantly less mean LPA and MVPA duration and greater ST duration than girls with normal weight During-school (all, $P \leq 0.05$). Gender-specific differences were also evident for average activity counts, LPA, MVPA and ST participation at various times throughout the day ($P < 0.01$). Additional analyses examined the proportion each time period contributed to overall participation in each activity intensity. These analyses revealed that the Before-school period explained the smallest proportion of overall PA and ST (7-8% of total LPA, 7-9% of total MVPA and 5% of total ST), the During-school period the greatest proportion (48-53% of total LPA, 49-53% of total MVPA and 44-47% of total ST), followed by the After-school period (18-20% of total LPA, 19-20% of total MVPA and 17-18% of total ST) (see Appendix 2).

Multivariate linear regression analyses, stratified by gender and adjusted for a range of covariates, were conducted to examine if weight status explained differences in mean activity counts, LPA, MVPA and ST participation across the school day as it was the greatest contributor to PA and SB participation (Table 2 and Table 3). Significant weight status differences were only evident for average activity counts, with boys with overweight/obesity having significantly lower counts.min^{-1} (β = -65.4; 95% CI: -119.99; -10.79 counts.min^{-1}). Among girls, those with overweight/obesity spent less time in LPA (β = -12.0; 95% CI: -

19.40; -4.61 mins.d^{-1}), MVPA (β = -5.7; 95% CI: -11.04; -0.44 mins.d^{-1}) and more time in ST (β = 20.2; 95% CI: 9.79; 30.64 mins.d^{-1}) than girls with normal weight. Significant age differences were also evident for both genders and are presented in the table.

Table 2.Multiple regression analysis of During-school PA and SB participation among boys

Variable	**Counts.min^{-1}**			**LPA**			**MVPA**			**SED**		
	β	95% CI	P	β	95% CI	P	β	95% CI	P	β	95% CI	P
Weight Status	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
Overweight/Obese (1)	**-65.39**	**(-119.99; -10.79)**	**0.019**	-2.0	(-9.28; 5.31)	0.590	-5.4	(-12.07; 1.27)	0.112	0.66	(-10.90; 12.22)	0.910
Age (Years)	**-21.84**	**(-46.32; 2.64)**	**0.08**	**-4.7**	**(-7.96; 1.43)**	**0.005**	-1.63	(-4.62; 1.37)	0.284	5.11	(-0.071 10.30)	0.053
SEIFA Quintile (Highest)	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
4th	-31.62	(-171.90; 108.66)	0.656	-2.0	(-20.74; 16.73)	0.832	-6.48	(-23.62; 10.67)	0.456	1.26	(-28.43; 30.95)	0.933
3rd	-1.98	(-156.15; 152.20)	0.980	-5.1	(-25.73; 15.45)	0.622	-12.17	(-31.01; 6.67)	0.203	4.64	(-28.00; 37.27)	0.779
2nd	7.44	(-130.77; 145.66)	0.915	-4.9	(-23.37; 13.55)	0.599	-9.07	(-25.96; 7.82)	0.290	9.80	(-19.46; 39.05)	0.508
Lowest	-69.96	(-204.53; 64.61)	0.305	-9.0	(-26.94; 9.01)	0.325	-9.05	(-25.49; 7.40)	0.278	10.80	(-17.68; 39.29)	0.454
Language [ESP (0) vs LOTE (1)	51.93	(-25.34; 129.18)	0.186	4.5	(-5.82; 14.81)	0.390	3.85	(-5.59; 13.29)	0.421	-12.98	(-29.33; 3.37)	0.118
LGA (school clusterering unit)	-1.48	(-6.08; 3.12)	0.534	-0.2	(-0.82; 0.41)	0.506	-0.42	(-0.98; 0.14)	0.143	0.24	(-0.73; 1.21)	0.625
Condition [Int (0) vs. Cont (1)]	7.62	(-47.86; 63.10)	0.786	-0.9	(-8.32; 6.50)	0.808	-3.04	(-9.82; 3.74)	0.376	8.99	(-2.76; 20.73)	0.132
Constant	630.15	(324.66; 935.64)	0.000	159.2	(118.43; 200.04)	0.000	92.98	(55.65; 130.31)	0.000	156.39	(91.73; 221.05)	0.000
R^2	0.11			0.10			0.08			0.09		
Adj R^2	0.04			0.02			0.01			0.02		
SEE (MRSE)	140.66			18.79			17.19			29.77		

Table 3.Multiple regression analysis of During-school PA and ST participation among girls

Variable	Counts.min-1			LPA			MVPA			ST		
	β	95% CI	P	β	95% CI	P	β	95% CI	P	β	95% CI	P
Weight Status	REF	REF	REF									
Overweight/Obese (1)	-22.74	(-81.81; 36.34)	0.448	**-12.0**	**(-19.40; -4.61)**	**0.002**	**-5.74**	**(-11.04; -0.44)**	**0.034**	**20.21**	**(9.79; 30.64)**	**0.000**
Age (Years)	-22.06	(-46.88; 2.76)	0.081	**-7.1**	**(-10.24; -4.04)**	**0.000**	-2.12	(-4.34; 0.11)	0.062	**8.56**	**(4.18; 12.94)**	**0.000**
SEIFA Quintile (Highest = 5th)	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
4th	-83.49	(-200.68; 33.71)	0.161	-4.3	(-18.92; 10.41)	0.568	-7.04	(-17.55; 3.48)	0.188	1.69	(-18.99; 22.38)	0.872
3rd	-20.18	(-144.87; 104.52)	0.750	4.5	(-11.11; 20.10)	0.570	-6.36	(-17.55; 4.82)	0.263	-8.99	(-31.00; 13.02)	0.421
2nd	-60.27	(-177.84; 57.30)	0.313	-12.2	(-26.89; 2.53)	0.104	-10.3	(-20.85; 0.25)	0.056	15.92	(-4.83; 36.67)	0.132
Lowest = 1st	-69.53	(-188.01; 48.96)	0.248	-7.1	(-21.91; 7.75)	0.347	-5.75	(-16.38; 4.88)	0.287	5.79	(-15.13; 26.70)	0.585
Language [ESP (0) vs LOTE (1)	**-88.05**	**(-164.49; -11.61)**	**0.024**	-0.8	(-10.37; 8.76)	0.868	-5.95	(-12.81; 0.91)	0.089	-2.91	(-16.40; 10.58)	0.671
LGA (school clusterering unit)	2.81	(-1.91; 7.52)	0.241	-0.1	(-0.543; 0.637)	0.875	-0.06	(-0.49; 0.36)	0.769	0.01	(-0.82; 0.85)	0.973
Condition [Int (0) vs. Cont (1)]	41.09	(-12.67; 94.86)	0.133	5.1	(-1.66; 11.80)	0.139	1.57	(-3.25; 6.40)	0.520	-2.08	(-11.57; 7.41)	0.665
Constant	684.77	(369.79; 999.76)	0.000	189.7	(150.27; 229.11)	0.000	84.15	(55.89; 112.41)	0.000	125.51	(69.91; 181.11)	0.000
R^2	0.08			0.22			0.10			0.22		
Adj R^2	0.03			0.18			0.05			0.18		
SEE (MRSE)	163.51			20.46			14.67			28.86		

Discussion

This study investigated the relationship between weight status and PA and SB participation across specific school-day time-periods among a sample of disadvantaged Victorian primary school boys and girls. Almost all participants met the physical activity guidelines (≥ 86%),[35] despite more than one in four children being classified as overweight or obese. In relation to the first research question which aimed to examine the composition of PA and ST participation across the school day; the During-school period (9am-3:30pm) represented the greatest accumulation of LPA and MVPA (between 48-53%) for both boys and girls. The second research question aimed to examine the influence of weight status on the composition of PA and ST across the school day by gender, with no significant weight status differences found for Before-school and After-school periods, regardless of gender. However, bivariate and adjusted multiple regression models found girls with overweight/obesity engaged in significantly less LPA and MVPA, and greater ST During-school than their peers within normal weight ($P \leq 0.05$). In addition, boys with overweight/obesity had significantly lower mean activity counts than boys with normal weight During-school ($P \leq 0.05$). The above findings from this study highlight the importance of improving both SB and PA in childhood obesity prevention efforts and the importance of schools as possible health-enhancing environments among children from disadvantaged areas.

Consistent with previous international research, this study found that Australian girls engaged in significantly less daily (total) MVPA than boys.[37 38] In addition, girls engaged in more ST than boys in total which has not previously demonstrated consistent gender differentials among children.[8 38] Gender differences in total and types of physical activity accelerate from observance at approximately 10-years of age,[40] which our results support, that girls are not closing this activity gap. When examining gender differences in participation within school, similar findings were observed and appear to be consistent with current international literature that suggests girls engage in less MVPA and more ST during-school hours,[17 18] and no significant difference in LPA.[18] One such study among 380 children (aged 8-11years) from Vancouver, Canada, found that during-school (9am-3pm) boys and girls engaged in on average 63 mins.d^{-1} and 53 mins.d^{-1} of MVPA, 56 mins.d^{-1} and 54 mins.d^{-1} of LPA and 246 mins.d^{-1} and 260 mins.d^{-1} of ST, respectively.[18] These findings are largely comparable with the current study, although it would appear that this Australian sample engaged in more LPA in preference to ST, although this may be simply reflect the differing classification of the school day (9am-3:30pm) in the present study.

This article extends the current knowledge base by examining the gender-specific association of weight status on LPA, MVPA and ST throughout defined periods of the school day; and, is believed to be the first study of its type among Australian school children. No significant differences were observed between children who were within the normal weight range and those with overweight/obesity for Before-school or After-school LPA, MVPA or ST participation in both the bivariate and multivariate analyses. However, the associations between During-school participation and weight status differed significantly among girls and girls. Compared to their peers with normal weight, boys with overweight/obesity engaged in significantly less average counts.min^{-1} and girls with overweight/obesity engaged in approximately -12 mins.d^{-1} less LPA and -6 mins.d^{-1} less MVPA and +20 mins.d^{-1} more ST after adjustment for covariates. The observation that weight status was significantly associated with PA participation throughout the school day among children is supported by a large multi-national European study.[17] The ENERGY study (Belgium, Greece, Hungary, Netherlands, Switzerland) among 1,025 children (aged 10-12 years) with complete accelerometry data found weight status predicted MVPA but not ST participation.[17] It was found that children with overweight/obesity spent significantly less time (4% vs 5%, $p \leq 0.01$) within the school-day engaged in MVPA compared to children with normal weight. A country-specific effect for the Netherlands was observed for ST, with children with overweight/obesity engaging in more ST (70% vs 66%, $p \leq 0.05$) compared to children with normal weight. These findings support our observances of differences in during-school participation by weight status, although of note is the observance that European children engaged in very little amounts of MVPA during-school (16 ± 9 $mins.d^{-1}$) compared to the current Australian sample (41-63 $mins.day^{-1}$). Varying country-specific differences, including seasonal differences, may be driving this observation as well as the varying accelerometry data handling and inclusion criteria employed in both studies.

We found that children were less active after-school than during-school, which is in contrast to the international notion that the 'After-school' period is a critical window for children's PA and can reflect up to 50% of PA engagement.[41] It is hypothesised that since children in the current study were sampled from communities that have been specifically identified as at-risk areas for chronic disease, the feasibility of after-school PA participation is realistically limited due to a variety of individual, environmental and psychosocial factors (e.g. costs, availability of transport to and from, parental-work commitments). For these communities, the school environment appears to be a critical setting for PA to be provided within school hours. Lessons learned from South Australian children (aged 10-13 years) [42] identified that the key barriers to after-school PA were safety for after-school active transport, distances to engage in PA opportunities and weather. Additionally, students identified perceived competence, enjoyment, being active with friends, school sport in preference to community sport due to distance, bullying, parental rules regarding participation and lack of time also impacted on after-school PA participation.[42] More research is therefore needed to identify the key facilitators and barriers to both during-school and after-school PA among children from disadvantaged communities to identify and implement possible solutions, particularly for girls.

Several limitations should be considered alongside the findings from this study, including assumptions underlying cross-sectional data. Firstly, the analyses sample emerged from a sub-sample of participants involved in the wider Healthy Together Victoria and Childhood Obesity study who were randomly assigned accelerometers due to the limited number available. Examination of this selection bias showed no significant difference between the included study sample and those excluded for insufficient wear, those excluded for lost/accelerometry error and those not given an accelerometer in mean age, gender distribution, SEIFA quintile or weight status. A significant differences was found for CALD background and participation/non-participation category, but this difference is likely to relate to the fact that 32 accelerometers were initialised incorrectly (set to 1-day instead of 7-day of monitoring) at one culturally and linguistically diverse primary school. However, the influence of non-participation bias can never be eliminated. Secondly, the utilisation of accelerometers involved many data-handling and management techniques which can directly influence the reported duration spent in intensities of PA[43] as they are not standardised.[44] The authors have opted for full-disclosure of all data handling and management techniques to increase the transparency of the achieved results. Specifically, we classified MVPA as ≥ 3 METs and used VM counts to classify activity intensity, as was done in the Romanzini equations.[32] Future research should look at the development of age-specific activity intensity cut-points using VM counts as there is evidence to suggest that energy expenditure varies by age and pubertal status.[45] Finally, the participants are drawn from communities selected for their high rates of chronic disease and levels of socioeconomic disadvantage,[1] and thus are not representative of the Victorian population but may reflect students whom are most-likely to be at risk.

Conclusion

Contrary to previous findings the during-school period constituted the greatest accumulation of MVPA for Grade 4 and Grade 6 children in the current sample. These findings highlight that among disadvantaged children, the school environment is a priority setting for interventions to promote PA at the expense of ST, especially among girls.

Author's contribution

Strugnell, Millar and Allender are all members of the executive committee overseeing the design, implementation and evaluation of the present study. Strugnell, Turner, Malakellis and Hayward were responsible for the collection, entry and cleaning of the data with Foster providing critical data management and analytic expertise of the accelerometry data. Strugnell led the development of the manuscript and all authors were involved in refining the paper and had final approval of the submitted and published versions.

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Competing interests

All authors affirm that they have no conflicts of interest and the funding agencies had no input to the design and conduct of the study.

Ethics approval

Prior to commencing this study ethical approvals from the Victorian Department of Education and Training (2013_002013), the Catholic Archdiocese of Melbourne, Sandhurst, Ballarat and Sale, and Deakin University's Human Research Ethics Committee (2013_095) were sought and granted.

Data sharing statement

No additional data are available

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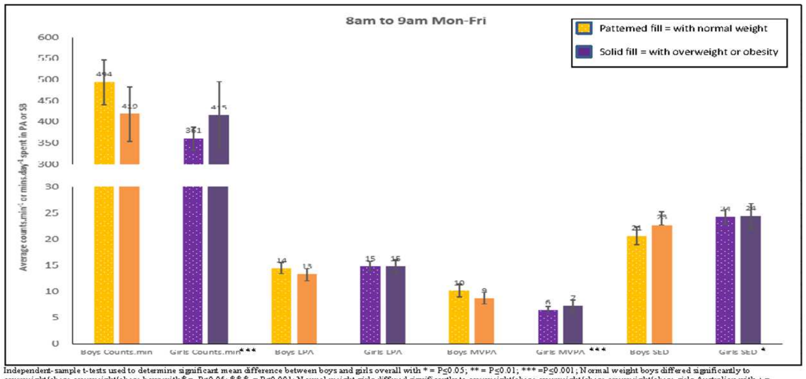
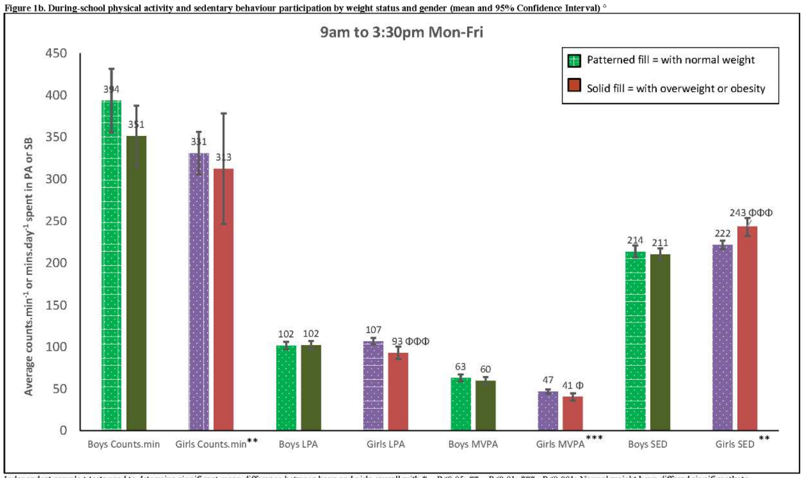
Figure 1a. Before-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) ª



Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Normal weight boys differed significantly to overweight/obese overweight/obese boys with Φ = P≤0.05; Φ Φ Φ = P≤0.001; Normal weight girls differed significantly to overweight/obese overweight/obese overweight/obese girls Australian with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ª = based on Greater than 600min.d⁻¹ of monitoring over => 3 days; § = Normal weight category included underweight.

297x210mm (120 x 97 DPI)

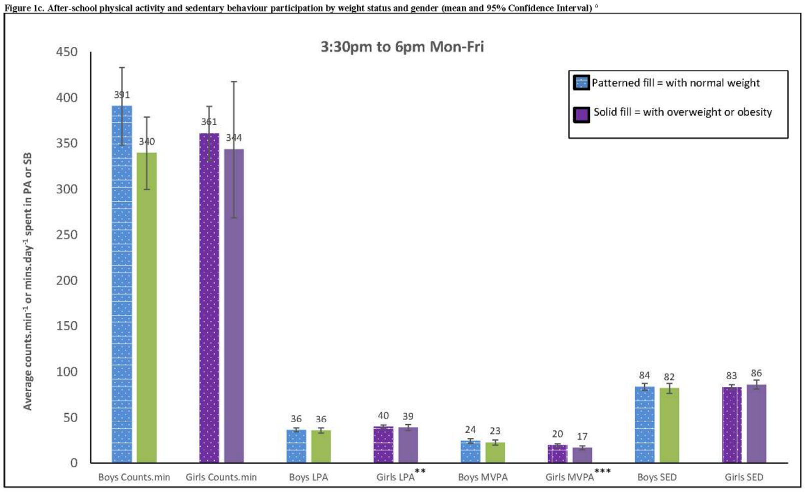
Figure 1b. During-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) °



Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Normal weight boys differed significantly to overweight/obese overweight/obese boys with Φ = P≤0.05; Φ Φ Φ = P≤0.001; Normal weight girls differed significantly to overweight/obese overweight/obese girls Australian with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ° = based on greater than 600min.d^{-1} of monitoring over => 3 days; § = Normal weight category included underweight.

297x210mm (200 x 200 DPI)

Figure 1c. After-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) ◊



Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Boys with normal weight differed significantly to boys with overweight/obesity Φ= P≤0.05; Φ Φ Φ = P≤0.001; Girls with normal weight differed significantly to girls with overweight/obesity + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ◊ = based on Greater than 600min.d-1 of monitoring over => 3 days; § = Normal weight category included underweight.

297x210mm (200 x 200 DPI)

Appendix 1. Demographic characteristics of the accelerometry sample (participants) compared to non-participants for this study

	Study sample Participants met minimum wear-time criteria (≥ 600min.d^{-1} over ≥ 3 days **(N= 298)**	**Excluded – Insufficient wear** Did not meet wear-time criteria **(N= 73)**	**Excluded – Lost/error** Accelerometer was lost or damaged/ incorrectly initialized, failed to download **(N= 63)**	**Excluded- Not given accelerometer** No accelerometer issued or refused, only random sub-set offered **(N=422)**
Age	11.2 (9.21; 13.24)	11.3 (9.55; 13.56)	10.9 (9.54; 13.00)	11.2 (9.51; 13.11)
Gender	44% boys	53% boys	52% boys	47% boys
Ethnicity- Language Other Than English	13.0%	21.9%	46.0%	23.2%
SEIFA Quintile (Highest = 5th)	24.6%	20.6%	30.2%	23.9%
4th	27.7%	31.5%	19.0%	28.7%
3rd	11.9%	21.9%	27.0%	16.9%
2nd	30.5%	21.9%	19.0%	26.3%
Lowest = 1st	5.3%	4.1%	4.8%	4.3%
Weight Status (with overweight/ obesity)	30.9%	27.1%	33.3%	34.3%

A One-way ANOVA was conducted to examine if there was a significant difference in mean aged between the four accelerometry/non-participant type with no significant difference observed (F(3, 852) = 5.1, p=0.228). A series of Pearson's chi-square tests were conducted for categorical variables with no significant difference in gender distribution (X^2_3 = 3.3, p = 0.351), SEIFA quintile (X^2_{12} = 16.7, p = 0.161), and weight status category observed between the four accelerometry/non-participant types (X^2_3 = 1.9, p = 0.604). However, a significant difference was detected for language spoken most commonly at home and the four accelerometry/non-participant types (X^2_3 = 36.1, p = 0.000).

Appendix 2. Contribution of the before-school, during-school and after-school period to overall (total) PA and SB participation

Gender and Weight status	Before-school (8am-9am)	During-school (9am-3:30pm)	After-school (3:30pm-6:00pm)	Combined (8am to 6:00pm)
	LPA	**LPA**	**LPA**	**LPA**
Boys Normal Weight (N = 82)	7.4 (6.97; 7.89)	52.5 (50.99; 53.90)	18.6 (17.72; 19.56)	78.5 (77.16; 79.86)
Boys Overweight/obese Overweight/obese (N= 48)	6.7 (6.27; 7.23)	52.2 (50.09; 54.24)	18.2 (17.05; 19.25)	77.1 (75.32; 78.81)
Girls Normal Weight (N= 124)	7.1 (6.72; 7.49)	51.2 (50.02; 52.37)	19.1 (18.47; 19.81)	77.4 (76.34; 78.54)
Girls Overweight/obese Overweight/obese (N=44)	7.8 7.18; 8.38)	48 (45.63; 50.38)	20.3 (18.89; 21.71)	76.1 (74.32; 77.86)
	MVPA	**MVPA**	**MVPA**	**MVPA**
Boys Normal Weight (N = 82)	8.4 (7.48; 9.35)	52.0 (49.94; 54.07)	19.7 (18.15; 21.24)	80.1 (78.43; 81.82)
Boys Overweight/obese Overweight/obese (N= 48)	7.6 (6.77; 8.49)	53.4 (50.17; 54.69)	19.0 (17.29; 20.74)	79.1 (77.18; 80.96)
Girls Normal Weight (N= 124)	**6.8 (6.21; 7.47)****	50.1 (48.33; 51.90)	20.4 (19.26; 21.61)	77.4 (75.86; 78.92)
Girls Overweight/obese Overweight/obese (N=44)	8.7 (7.49; 9.96)	48.8 46.15; 51.40)	20.1 (18.20; 22.03)	77.6 (75.69; 79.54)
	SED	**SED**	**SED**	**SED**
Boys Normal Weight (N = 82)	4.5 (4.14; 4.92)	**47.0 (45.29; 48.73)***	**18.3 (17.55; 19.06)***	78.5 (77.16; 79.86)
Boys Overweight/obese Overweight/obese (N= 48)	4.7 (4.21; 5.21)	44.1 (41.98; 46.28)	17.0 (15.97; 18.06)	77.1 (75.32; 78.81)
Girls Normal Weight (N= 124)	5.0 (4.74; 5.34)	46.2 (44.87; 47.55)	17.3 (16.68; 17.90)	77.4 (76.34; 78.54)
Girls Overweight/obese Overweight/obese (N=44)	4.8 (4.27; 5.34)	47.3 (45.61; 48.92)	16.8 (15.86; 17.79)	76.1 (74.32; 77.86)

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Composition of objectively measured physical activity and sedentary behaviour participation across the school-day, influence of gender and weight status: cross-sectional analyses among disadvantaged Victorian school children

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Strengths and limitations of this study

- This study has various strengths that centre on the objective examination of the physical activity and sedentary behaviour across the school-day with measured anthropometric indices among disadvantaged primary school children.
- Additionally, this study examines the importance of the before-school, during-school and after-school period for physical activity and sedentary behaviour participation which are commonly examined in isolation, with many studies focussing on the after-school period.
- A limitation of this study is the cross-sectional nature of the data that arises from a sub-sample of possible participants due to the limited number of accelerometers available to the study team.
- Another limitation is the sampling strategy used which deliberately focussed on local government areas with high rates of chronic disease and levels of socioeconomic disadvantage, and thus are not representative of the Victorian population.

Abstract

Background

The after-school period has been described as the 'critical window' for physical activity (PA) participation. However, little is known about the importance of this window compared to the before and during-school period among socioeconomically disadvantaged children, and influence of gender and weight status.

Methods

Thirty-nine out of 156 (RR= 25%) invited primary schools across 26 local government areas in Victoria, Australia, consented to participate with 856 children (RR= 36%) participating in the wider study. The analysis sample included 298 Grade 4 and Grade 6 children (mean age: 11.2 ± 1.1; 44% male) whom met minimum accelerometry wear-time criteria and had complete height, weight and health-behaviours questionnaire data. Accelerometry measured duration in daily light-intensity PA (LPA), moderate-to-vigorous PA (MVPA) and sedentary time (ST) was calculated for Before-school = 8-8:59am, During-school = 9am-3:29pm, and After-school = 3:30pm-6pm. Bivariate and multivariable linear regression analyses were conducted.

Results

During-school represented the greatest accumulation of LPA and MVPA compared to the Before and After-school periods. Boys engaged in 102 mins.d^{-1} of LPA (95% CI: 98.5, 104.9) and 62 mins.d^{-1} of MVPA (95% CI: 58.9, 64.7) During-school; girls engaged in 103 mins.d^{-1} of LPA (95% CI: 99.7, 106.5) and 45 mins.d^{-1} of MVPA (95% CI 42.9, 47.4). Linear regression models indicated that girls with overweight or obesity engaged in significantly less LPA, MVPA and more time in ST During-school.

Conclusions

This study highlights the importance of in-school PA compared to after-school PA among socioeconomically disadvantage children whom may have fewer resources to participate in after-school PA.

250/250 abstract word count

Introduction

Regular physical activity (PA) participation has many documented health benefits for children and adolescents.[1 2] Low levels of physical activity (termed physical inactivity) among youths has been associated with negative outcomes including lower high-density lipoprotein cholesterol, hypertension, metabolic syndrome and obesity[1] and increased mental health outcomes (depression, anxiety, self-esteem and cognitive function).[3] Representative self-report data indicate that approximately 80.4% of Australian children and adolescents (aged 5-17 years)[4] engaged in insufficient levels of moderate-to-vigorous physical activity (MVPA) to confer the health benefits (≥ 60mins.d^{-1} of MVPA every day).[5] Together with high levels of sedentary behaviours (SB),[4] which are also linked to negative health,[6] physical inactivity remains a pressing public health concern.

A variety of individual, environmental and psychosocial influences have been associated with PA and SB participation.[7 8] Parallels exist with obesity which is also now accepted to result from a complex array of influences.[9] Single interventions have provided modest changes in child and adolescent PA[10 11] and SB[12 13] leading to a shift in focus to multi-component interventions.[10 11] Schools have become a key setting for single and multiple intervention approaches targeting increasing PA and reduction of SB. The focus on schools is logical due to the sheer volume of time children spend in school and the strong structures (e.g. policy, governance, curriculum, and fiscal) that both influence these environments and are relatively easy to manipulate to try and change PA and SB behaviours. Improvements in physical activity and nutrition within the school will also help address inequities, as they offer an unsurpassed opportunity to reach all children.[14] Health equity has been defined as "the absence of potentially remediable, systematic difference in one or more aspects of health across socially, economically, demographically, or geographically defined population groups or subgroup".[15] Although, it is acknowledged that schools cannot singularly reverse physical inactivity and SB, but offer great potential in ensuring students achieve the recommended amount MVPA.[10 14]

Efforts to understand the effectiveness of interventions and participation behaviours in schools are hampered by a lack of objective measurement of PA and sedentary behaviour time (ST) across the whole school day.[16] This is emphasised by the limited international literature. Variations in school times and durations appear to be strong determinants of MVPA and ST among school-aged children.[17] A five country European study (Belgium, Greece, Hungary, the Netherlands, Switzerland) among 1,025 children (aged 10-12 years) with valid accelerometry found students spent 4-6% (approx. 13-21 mins-d^{-1}) of the school-day in MVPA and 61-70% (approx. 182-231 mins.d^{-1}) in ST.[17] In addition, a Canadian study among 380 children (aged 8-11 years) found that 14% of and 71% of the school-day was spent in MVPA and ST, respectively, for girls (approx. 53 mins.d^{-1} MVPA and 260 mins.d^{-1} ST) and 17% and 67% for boys (approx. 64 mins.d^{-1} MVPA and 246 mins.d^{-1} ST).[18] To date, it is believed that there is no objective measurement of PA and ST participation across the entire school day (Before, During, After-school) and associations with weight status within the Australian primary school context.

This paper reports on the segmented patterns of PA and ST among Grade 4 and Grade 6 Australian primary school children with valid accelerometry data during Sept-Dec 2013 (Term 4). The paper sets out to answer the following questions:

1. What is the composition of PA and ST before-school, during-school and after-school among predominantly socioeconomically disadvantaged primary school children?

2. What influence does weight status have on the composition of PA and ST across the school-day and does this vary by gender?

It is hypothesised that the during-school period will represent the greatest accumulation of physical activity among the current sample and that children with overweight or obesity will engage in significantly less PA and ST before, during and after-school than their peers with healthy weight.

Methods

Setting, study population and sampling

This cross-sectional pilot data derives from the Healthy Together Victoria (HTV) and Childhood Obesity study which aims to measure the impacts of HTV on anthropometric and obesogenic behaviours among Victorian children and the environments in which they live. Embedded within HTV is a cluster-randomised control trial of 12 prevention and 12 comparison clusters which were selected through their matched randomisation based on their demographic [Socioeconomic Index for Areas (SEIFA)][19] and chronic disease risk factor prevalence (i.e. unhealthy weight)] of adults within participating LGAs. This study involved the collection of anthropometric and behavioural data among primary and secondary school children from 26 local government areas (LGAs); the details of which have previously been published.[20] In brief, a randomly selected subset of schools from a list of all public and independent primary schools were invited to participate within each LGA. One hundred and fifty-six primary schools were invited during Term 4 (September to December 2013), with 39 schools consenting to participate (school-level response rate (RR) = 25%). Within these schools, all Grade 4 and Grade 6 students were invited (N = 2,357) with 856 parent/guardian consents received through the return of the signed parent/guardian consent form (student-level RR = 36%). In order to examine the segmented patterns of PA and ST, a sub-sample of students who were provided with an accelerometer is utilized in this article (see Appendix 1 for a detailed overview of accelerometry and non-accelerometry participants). Prior to commencing this study ethical approvals from the Victorian Department of Education and Training (2013_002013), the Catholic Archdiocese of Melbourne, Sandhurst, Ballarat and Sale, and Deakin University's Human Research Ethics Committee (2013_095) were sought and granted.

Measures and data management

All participants completed a self-report questionnaire during class (20-35 mins) which collected demographic (date of birth, gender, residential postcode, language spoken at home, country of birth and ancestry), PA and SB participation,[21 22] diet quality[23 24] and perceived health and wellbeing.[25] Participants were also invited to have their height and weight measured by trained research assistants during class time (3-5 mins per student). While the anthropometric measurements were taking place, a random sub-sample were also invited to wear an accelerometer for the proceeding 7-days. The engagement of a sub-sample was necessary due to the limited number of accelerometers; therefore, every second boy and girl in Grade 4 and Grade 6 (e.g. 1st Grade 6 boy and girl, 3rd Grade 6 boy and girl etc.) was invited to wear an accelerometer.

Self-reported residential suburb/postcode was used to categorise individuals within quintiles of Relative Socio-economic Advantage and Disadvantage (IRSAD) which was derived from the Australian Bureau of Statistics (ABS) Socio-Economic Indexes for Areas (SEIFA) index from the 2011 Australian Census.[19] Self-reported language spoken predominantly at home was used to categorise individuals into two categories (English speaking and Language other than English) as a measure of culture and linguistic diversity.[26] The term recognises that groups and individuals differ according to ethnicity, language, race, religion and spirituality and the term CALD is often used to describe groups that differ from the English speaking majority (non-CALD).[26]

Height was measured to the nearest 0.5 cm using a portable stadiometer (Charder HM-200P Portstad, Charder Electronic Co Ltd, Taichung City, Taiwan) and weight to the nearest 0.1 kg using an electronic weight scale (A&D Precision Scale UC-321; A7D Medical, San Jose, CA) without shoes and whilst wearing light clothing. Age and sex-specific body mass index (BMI) z-scores and weight status categories were calculated using the World Health Organization's growth reference.[27]

The ActiGraph GT3X and GT3X+ accelerometer models (ActiGraph, Pensacola, FL) were utilized and participants were instructed to wear the activity monitor on the right hip during waking hours, excluding water based and sparring activities (e.g. boxing). The intergenerational issue of the differing ActiGraph accelerometer models was overcome by selecting a 15-second epoch and 30-hertz sampling rate, which has previously been shown to have strong agreement with total vertical axis counts, total vector magnitude (VM) counts and MVPA among children and adolescents.[28] Nonwear-time was identified by periods in which ≥ 60 minutes of consecutive zero counts were obtained, with a 1-2 minute allowance of counts between 0 and 100.[29] Wear-time was calculated by subtracting nonwear-time from 24 hours. A valid day of wear was considered if ≥ 600 minutes per day (mins.d^{-1}) [29] of wear-time was recorded over a minimum ≥ 3 days; reliable estimates of children's physical activity have been observed with ≥ 600 mins.d^{-1} of monitoring over a minimum of ≥ 2 days.[30] Total vector magnitude (VM) counts per minute (counts.min^{-1}) were calculated to give an indication of overall volume of PA. The VM counts utilise information from three axes via the equation $VM = \sqrt{(Axis\ 1)^2 + (Axis\ 2)^2 + (Axis\ 3)^2}$ and were calculated per epoch of time.[31] Metabolic equivalent units (METs) were assigned to VM counts.min^{-1} to classify the intensity of activity as: sedentary (ST) ≤ 1.5 METs, light (LPA) = 1.5 to 2.9 METs, and moderate-to-vigorous (MVPA) ≥ 3.0 METs[32] using the validated accelerometer cut-points developed by Romanzini et al., (2014).[33] Whilst newer accelerometer models can capture three axes of data,[34] the reporting of this information is less apparent than the singular vertical axis (Axis 1).

Temporal patterns of PA and ST participation during the week were examined using three distinct time-periods that reflected the typical cadence of the school day (Before-school = 8am to 8:59am; During-school = 9am to 3:29pm; and After-school = 3:30pm to 6:00pm). These time-periods were selected to reflect the Australian education environment as well as the time periods commonly used to define the after-school period.[35] Durations spent in sedentary (ST), light (LPA) and moderate-to-vigorous (MVPA) activity within these specific temporal windows were examined as well as durations spent in daily (Mon-Sun) activity. The contribution (proportion) of each of these distinct time-periods to overall ST, LPA and MVPA was calculated by the following formula [100/ Total participation (Mon-Fri) in the respective intensity] X participation in the interested time-period and intensity (Mon-Fri)]. Adherence to the Australian National Physical Activity Guidelines[36] was examined using the averageXdays method,[37] whereby a child is considered compliant if MVPA duration on average exceeds ≥ 60 mins.d^{-1} of MVPA.

Statistical analyses

Only participants with complete anthropometric, questionnaire and accelerometry data were included in the analyses (N = 298). No differences were identified in mean age, gender distribution, SEIFA quintile or weight status category between the analysis sample and those not included for analyses (non-participants), although CALD status differed significantly suggesting that proportionally more CALD background were non-participants for various reasons ($P \leq 0.001$) (Appendix 1). Statistical analyses were conducted using STATA 12.0 (STATA Corp., College Station, Texas, USA). Initial analyses examined whether mean BMI-z score or average MVPA duration differed between intervention and comparison participants using a multilevel mixed-effects linear regression analysis and had valid accelerometry (N= 298 participants). No significant differences were detected by condition (intervention vs. comparison), supporting the subsequent analyses on combined cross-sectional data.

Independent sample t-tests examined if gender differences were evident as well as differences in weight status category for demographic and behavioural variables, Cohen's (d) effect size for independent samples was also calculated and interpreted as: 0.0-0.19 (trivial effect), 0.20-0.49 (small effect), 0.50- 0.79 (medium effect), and 0.80 or higher (large effect).[38] Pearson's Chi-square tests were used to examine differences in proportions. A series of independent linear regression analyses examined the relationship between the dependent variables (MVPA, LPA, ST) and weight status [healthy weight (reference) and overweight/obesity] During-school, whilst controlling for the potential influences of age, socioeconomic position [(SEP), highest 5th quintile (reference)] study condition [intervention (reference) or comparison] and cluster-based sampling (with LGA utilized as the cluster unit). The regression analyses were stratified by gender since gender is a significant predictor of PA among children[39 40] and separate models were used for MVPA, LPA and ST because sedentary behaviour can be independent of physical activity participation.[41] Significance was set at $P<0.05$ for all analyses.

Results

Table 1 presents the demographic characteristics of participants with complete accelerometry data by gender and weight status. No significant gender or weight status differences were observed for age, CALD status, SEIFA quintile, accelerometer wear-time, and number of valid weekdays or weekend days of accelerometer monitoring. However, among boys the mean BMI-z score was higher, daily activity counts.min^{-1} and average daily MVPA duration were higher and daily ST was lower compared to girls (all, $P \leq 0.05$). Cohen's effect size demonstrated large effect for gender differences for MVPA duration only ($d = 1.0$).[38] Girls with overweight/obesity engaged in significantly lower levels of daily LPA, MVPA and higher levels of ST than girls in the healthy weight range, with small effect sizes observed ($d = 0.26$-0.48). On average, participants spent approximately 8hrs.d^{-1} engaged in ST, 3hrs.d^{-1} in LPA and 1.5hrs.d^{-1} in MVPA regardless of gender or weight status.

Table 1. Descriptive characteristics and unadjusted physical activity and sedentary behaviour patterns of participants (Mean + 95% CI)

		N	Total	Difference Boys vs. Girls		N	Healthy weight§	N	Overweight or Obese	Difference (Healthy weight vs. Overweight or Obesity)	
			(Mean ± 95% CI)	(Mean Diff ± 95% CI)	Effect size (d)		(Mean ± 95% CI)		(Mean ± 95% CI)	(Mean Diff ± 95% CI)	Effect Size (d)
Age (years)											
Boys	(M)	130	11.3 (11.10, 11.48)	0.1 (-0.12; 0.37)	0.12	82	11.4 (11.18, 11.64)	48	11.1 (10.77, 11.41)	0.3 (-0.06; 0.71)	0.30
Girls	(F)	168	11.2 (11.01, 11.32)			124	11.1 (10.92, 11.29)	44	11.3 (11.04, 11.64)	-0.2 (-0.59; 0.12)	-0.23
Ethnicity- Language											
(Language Other Than English)	(M)	17	13.60%			8	10.26%	9	19.15%		
	(F)	21	12.50%			16	12.90%	5	11.36%		
SEIFA quintile (%)											
Lowest Quintile	(M)	37	30.33%			25	32.47%	12	26.67%		
	(F)	33	20.25%			27	22.13%	6	14.63%		
BMI-z	(M)	130	0.6 (0.41, 0.84)	0.3 (0.49; 0.58)	0.27	82	-0.1 (-0.31, 0.03)	48	1.9 (1.77, 2.10) ΦΦΦ	-2.1 (-2.33; -1.82)	-2.95
	(F)	168	0.3 (0.15, 0.48)*			124	-0.2 (-0.31, -0.04)	44	1.7 (1.51, 1.85) +++	-1.9 (-2.10; -1.61)	-2.59
Valid wear (days)											
Valid weekdays	(M)	130	3.9 (3.75, 4.08)	0.1 (-0.13; 0.33)	0.10	82	3.8 (3.64, 4.05)	48	4.0 (3.76, 4.32)	-0.2 (-0.54; 0.14)	-0.21
	(F)	168	3.8 (3.66, 3.97)			124	3.8 (3.64, 4.00)	44	3.8 (3.45, 3.14)	0.0 (-0.33; 0.39)	0.03
Valid weekend days	(M)	130	1.3 (1.15, 1.43)	0.0 (-0.17; 0.18)	0.01	82	1.3 (1.17, 1.51)	48	1.2 (0.99, 1.43)	0.1 (-0.14; 0.41)	0.17
	(F)	168	1.3 (1.17, 1.40)			124	1.3 (1.20, 1.46)	44	1.2 (0.91, 1.40)	0.2 (-0.09; 0.43)	0.23
Daily wear-time (min.d^{-1})⌂	(M)	130	789.4 (774.99, 803.71)	-4.0 (-23.33; 15.37)	-0.05	82	779.7 (763.42, 796.01)	48	805.8 (778.43, 833.19)	-26.1 (-55.62; 2.44)	-0.32
(Mon-Sun)	(F)	168	793.3 (780.35, 806.31)			124	792.4 (775.95, 808.86)	44	796.0 (777.46, 814.44)	-3.6 (-33.16; 26.07)	-0.04

Daily activity counts (counts.m^{-1})$^{\triangle}$ (Mon-Sun)	(M)	130	261.3 (244.28, 278.31)	33.5 (12.15; 54.85)	0.36	82	269.1 (247.63, 290.57)	48	248.0 (219.45, 276.48)	21.1 (-14.06; 56.34)	0.22
	(F)	168	227.8 (214.29; 241.30) **			124	233.8 (217.69,249.85)	44	210 (186.00, 235.90)	22.8 (-7.79; 53.43)	0.26
Daily Sedentary (min.d^{-1})$^{\triangle}$	(M)	130	479.0 (463.41, 494.57)	-24.3 (-45.20; -3.46)	-0.27	82	469.0 (450.72, 487.17)	48	496.1 (467.41, 524.88)	-27.2 (-59.26; 4.86)	-0.31
(Mon-Sun)	(F)	168	503.3 (489.37, 517.26) *			124	495.0 (478.00, 511.93)	44	526.9 (503.86, 549.85) +	-31.9 (-63.32; -0.46)	-0.35
Daily LPA (min.d^{-1})$^{\triangle}$	(M)	130	192.7 (187.30; 198.12)	-7.9 (-15.76; 0.7)	-0.23	82	191.3 (184.13, 198.54)	48	195.1 (186.80, 203.33)	-3.7 (-14.97; 7.51)	-0.12
(Mon-Sun)	(F)	168	200.6 (194.96, 206.15)			124	204.6 (198.25, 210.95)	44	189.2 (177.74, 200.57) +	15.5 (2.90; 28.00)	0.43
Daily MVPA (min.d^{-1})$^{\triangle}$	(M)	130	116.7 (111.58, 121.84)	28.3 (21.80; 34.70)	1.01	82	118.5 (112.03, 124.97)	48	113.7 (105.02, 122.29)	4.9 (-5.75; 15.48)	0.16
(Mon-Sun)	(F)	168	88.5 (84.37, 92.56) ***			124	91.8 (86.97, 96.60)	44	79.1 (71.73, 86.43) ++	12.7 (3.58; 21.85)	0.48
Meeting MVPA guidelines	(M)	126	96.9%			80	97.6%	46	95.8%		
(Average Method %) (Mon-Sun)	(F)	144	85.7% **			112	90.3%	32	72.7%++		

Independent-sample t-tests or chi-square tests used to determine significant mean or proportional differences between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Cohen's d effect size was calculated for mean differences in ratio data; Boys with healthy weight boys differed significantly to boys with overweight/obesity $^{\Phi}$= P≤0.05; $^{\Phi\Phi\Phi}$ = P≤0.001; Girls with healthy weight girls differed significantly to girls with overweight/obesity with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); $^{\triangle}$= based on Greater than 600min.d^{-1} of monitoring over => 3 days; and SEIFA = Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD); § = Healthy weight category included underweight

Participation in PA and ST across the three specific school-day time-periods (Before-school (8am-9am), During-school (9am-3:30pm) and After-school (3:30-6pm) are presented in Table 2 by gender and graphically in Figures 1a-1c by weight status and gender. Bivariate analyses revealed significant gender difference in MVPA participation between boys and girls before and During-school which was confirmed with medium (d = 0.69) and large effect sizes (d= 1.05), respectively. No significant differences between boys in the healthy weight range and those in the overweight/obese range within the Before-school, During-school or After-school period for average activity counts, LPA, MVPA or ST duration. In contrast, among girls, significant differences were evident between the weight status categories within the During-school period. Those with overweight/obesity had significantly less mean LPA and MVPA duration and greater ST duration than girls with healthy weight During-school (all, $P \leq 0.05$). Gender-specific differences were also evident for average activity counts, LPA, MVPA and ST participation at various times throughout the day ($P < 0.01$). Additional analyses examined the proportion each time period contributed to overall participation in each activity intensity. These analyses revealed that the Before-school period explained the smallest proportion of overall PA and ST (7-8% of total LPA, 7-9% of total MVPA and 5% of total ST), the During-school period the greatest proportion (48-53% of total LPA, 49-53% of total MVPA and 44-47% of total ST), followed by the After-school period (18-20% of total LPA, 19-20% of total MVPA and 17-18% of total ST) (see Appendix 2).

Table 2. **Before-school physical activity and sedentary behaviour participation by gender**⌂

	N	Total	Difference Boys vs. Girls	
		(Mean ± 95% CI)	(Mean Diff ± 95% CI)	Effect size (d)
Before-school (8-9 am) Mon-Fri				
Activity counts (counts.m^{-1})⌂				
Boys	130	466.6 (425.59; 507.53)	91.2 (42.69; 139.68)***	0.43
Girls	168	375.4 (345.56; 404.16)		
Sedentary (min.d^{-1})⌂				
Boys	130	21.4 (20.03; 22.85)	-2.9 (-4.72; -1.04)**	-0.36
Girls	168	24.3 (23.11; 25.53)		
LPA (min.d^{-1})⌂				
Boys	130	14.0 (13.24; 14.80)	-0.82 (-1.90; 0.26)	-0.18
Girls	168	14.8 (14.10; 15.57)		
MVPA (min.d^{-1})⌂				
Boys	130	9.6 (8.78; 10.54)	3.0 (2.00; 4.03)***	0.69
Girls	168	6.6 (6.06; 7.22)		
During-school (9:00-3:30pm) Mon-Fri				
Activity counts (counts.m^{-1})⌂				
Boys	130	378.0 (350.66; 405.41)	51.9 (14.74; 89.04)**	0.32
Girls	168	326.2 (301.09; 351.20)		
Sedentary (min.d^{-1})⌂				
Boys	130	212.7 (207.49; 217.83)	-14.6 (-21.74; -7.53)***	-0.47
Girls	168	227.3 (222.46; 232.13)		
LPA (min.d^{-1})⌂				
Boys	130	101.7 (98.46; 104.93)	-1.4 (-6.21; 3.41)	-0.06
Girls	168	103.1 (99.66; 106.53)		
MVPA (min.d^{-1})⌂				
Boys	130	61.8 (58.85; 64.73)	16.6 (12.98; 20.25)***	1.05
Girls	168	45.2 (42.91; 47.44)		
After-school (3:30-6:00pm) Mon-Fri				
Activity counts (counts.m^{-1})⌂				
Boys	130	372.0 (341.45; 402.49)	15.6 (-26.69; 57.80)	0.08
Girls	168	356.4 (327.54; 385.30)		
Sedentary (min.d^{-1})⌂				
Boys	130	83.2 (80.16; 86.32)	-0.9 (-4.85; 3.01)	-0.05
Girls	168	84.2 (81.64; 86.68)		
LPA (min.d^{-1})⌂				
Boys	130	36.1 (34.41; 37.78)	-3.6 (-5.91; -1.33)**	-0.36
Girls	168	39.7 (38.17; 41.26)		
MVPA (min.d^{-1})⌂				

Boys	130	23.6 (21.77; 25.51)	4.8 (2.54; 7.00)***	0.49
Girls	168	18.9 (17.54; 20.21)		

Independent-sample t-tests used to determine significant mean or proportional differences between boys and girls overall with * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$; Cohen's d effect size was calculated for mean differences in ratio data; ⌂ = based on Greater than 600min.d^{-1} of monitoring over => 3 days.

Multivariable linear regression analyses, stratified by gender and adjusted for a range of covariates, were conducted to examine if weight status explained differences in mean activity counts, LPA, MVPA and ST participation across the school day as it was the greatest contributor to PA and SB participation (Table 3 and Table 4). Significant weight status differences were only evident for average activity counts, with boys with overweight/obesity having significantly lower counts.min^{-1} (β = -65.4; 95% CI: -119.99; -10.79 counts.min^{-1}). Among girls, those with overweight/obesity spent less time in LPA (β = -12.0; 95% CI: -19.40; -4.61 mins.d^{-1}), MVPA (β = -5.7; 95% CI: -11.04; -0.44 mins.d^{-1}) and more time in ST (β = 20.2; 95% CI: 9.79; 30.64 mins.d^{-1}) than girls with healthy weight. Significant age differences were also evident for both genders and are presented in the table.

Table 3.Multiple regression analysis of During-school PA and SB participation among boys

Variable	Counts.min^{-1}			LPA			MVPA			SED		
	β	95% CI	P	β	95% CI	P	β	95% CI	P	β	95% CI	P
Weight Status	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
Overweight/Obese (1)	**-65.39**	**(-119.99; -10.79)**	**0.019**	-2.0	(-9.28; 5.31)	0.590	-5.4	(-12.07; 1.27)	0.112	0.66	(-10.90; 12.22)	0.910
Age (Years)	**-21.84**	**(-46.32; 2.64)**	**0.08**	**-4.7**	**(-7.96; 1.43)**	**0.005**	-1.63	(-4.62; 1.37)	0.284	5.11	(-0.071 10.30)	0.053
SEIFA Quintile (Highest)	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
4th	-31.62	(-171.90; 108.66)	0.656	-2.0	(-20.74; 16.73)	0.832	-6.48	(-23.62; 10.67)	0.456	1.26	(-28.43; 30.95)	0.933
3rd	-1.98	(-156.15; 152.20)	0.980	-5.1	(-25.73; 15.45)	0.622	-12.17	(-31.01; 6.67)	0.203	4.64	(-28.00; 37.27)	0.779
2nd	7.44	(-130.77; 145.66)	0.915	-4.9	(-23.37; 13.55)	0.599	-9.07	(-25.96; 7.82)	0.290	9.80	(-19.46; 39.05)	0.508
Lowest	-69.96	(-204.53; 64.61)	0.305	-9.0	(-26.94; 9.01)	0.325	-9.05	(-25.49; 7.40)	0.278	10.80	(-17.68; 39.29)	0.454
Language [ESP (0) vs LOTE (1)	51.93	(-25.34; 129.18)	0.186	4.5	(-5.82; 14.81)	0.390	3.85	(-5.59; 13.29)	0.421	-12.98	(-29.33; 3.37)	0.118
LGA (school clusterering unit)	-1.48	(-6.08; 3.12)	0.534	-0.2	(-0.82; 0.41)	0.506	-0.42	(-0.98; 0.14)	0.143	0.24	(-0.73; 1.21)	0.625
Condition [Int (0) vs. Cont (1)]	7.62	(-47.86; 63.10)	0.786	-0.9	(-8.32; 6.50)	0.808	-3.04	(-9.82; 3.74)	0.376	8.99	(-2.76; 20.73)	0.132
Constant	630.15	(324.66; 935.64)	0.000	159.2	(118.43; 200.04)	0.000	92.98	(55.65; 130.31)	0.000	156.39	(91.73; 221.05)	0.000
R^2	0.11			0.10			0.08			0.09		
Adj R^2	0.04			0.02			0.01			0.02		
SEE (MRSE)	140.66			18.79			17.19			29.77		

Table 4.Multiple regression analysis of During-school PA and ST participation among girls

Variable	Counts.min-1			LPA			MVPA			ST		
	β	95% CI	P	β	95% CI	P	β	95% CI	P	β	95% CI	P
Weight Status	REF	REF	REF									
Overweight/Obese (1)	-22.74	(-81.81; 36.34)	0.448	**-12.0**	**(-19.40; -4.61)**	**0.002**	**-5.74**	**(-11.04; -0.44)**	**0.034**	**20.21**	**(9.79; 30.64)**	**0.000**
Age (Years)	-22.06	(-46.88; 2.76)	0.081	**-7.1**	**(-10.24; -4.04)**	**0.000**	-2.12	(-4.34; 0.11)	0.062	**8.56**	**(4.18; 12.94)**	**0.000**
SEIFA Quintile (Highest = 5th)	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
4th	-83.49	(-200.68; 33.71)	0.161	-4.3	(-18.92; 10.41)	0.568	-7.04	(-17.55; 3.48)	0.188	1.69	(-18.99; 22.38)	0.872
3rd	-20.18	(-144.87; 104.52)	0.750	4.5	(-11.11; 20.10)	0.570	-6.36	(-17.55; 4.82)	0.263	-8.99	(-31.00; 13.02)	0.421
2nd	-60.27	(-177.84; 57.30)	0.313	-12.2	(-26.89; 2.53)	0.104	-10.3	(-20.85; 0.25)	0.056	15.92	(-4.83; 36.67)	0.132
Lowest = 1st	-69.53	(-188.01; 48.96)	0.248	-7.1	(-21.91; 7.75)	0.347	-5.75	(-16.38; 4.88)	0.287	5.79	(-15.13; 26.70)	0.585
Language [ESP (0) vs LOTE (1)	**-88.05**	**(-164.49; -11.61)**	**0.024**	-0.8	(-10.37; 8.76)	0.868	-5.95	(-12.81; 0.91)	0.089	-2.91	(-16.40; 10.58)	0.671
LGA (school clusterering unit)	2.81	(-1.91; 7.52)	0.241	-0.1	(-0.543; 0.637)	0.875	-0.06	(-0.49; 0.36)	0.769	0.01	(-0.82; 0.85)	0.973
Condition [Int (0) vs. Cont (1)]	41.09	(-12.67; 94.86)	0.133	5.1	(-1.66; 11.80)	0.139	1.57	(-3.25; 6.40)	0.520	-2.08	(-11.57; 7.41)	0.665
Constant	684.77	(369.79; 999.76)	0.000	189.7	(150.27; 229.11)	0.000	84.15	(55.89; 112.41)	0.000	125.51	(69.91; 181.11)	0.000
R^2	0.08			0.22			0.10			0.22		
Adj R^2	0.03			0.18			0.05			0.18		
SEE (MRSE)	163.51			20.46			14.67			28.86		

Discussion

This study investigated the relationship between weight status and PA and SB participation across specific school-day time-periods among a sample of disadvantaged Victorian primary school boys and girls. Almost all participants met the physical activity guidelines (≥ 86%)[36] using the averageXdays method, [37] despite more than one in four children being classified as overweight or obese. In relation to the first research question which aimed to examine the composition of PA and ST participation across the school day; the During-school period (9am-3:30pm) saw the greatest accumulation of LPA and MVPA for both boys and girls. The second research question aimed to examine the influence of weight status on the composition of PA and ST across the school day by gender, with no significant weight status differences found for Before-school and After-school periods, regardless of gender. However, bivariate and adjusted multiple regression models found girls with overweight/obesity engaged in significantly less LPA and MVPA, and greater ST During-school than their peers with healthy weight ($P \leq 0.05$). In addition, boys with overweight/obesity had significantly lower mean activity counts than boys with healthy weight During-school ($P \leq 0.05$). The above findings from this study highlight the importance of improving both SB and PA in childhood obesity prevention efforts and the importance of schools as possible health-enhancing environments among children from disadvantaged areas.

Consistent with previous international research, this study found that Australian girls engaged in significantly less daily (total) MVPA than boys, which was supported by the strong effect size.[39 40] In addition, girls engaged in more ST than boys in total, with medium effect size, which has not previously demonstrated consistent gender differentials among children.[7 40] Gender differences in total and types of physical activity accelerate from observance at approximately 10-years of age,[42] which our results support, that girls are not closing this activity gap. When examining gender differences in participation within school, similar findings were observed and appear to be consistent with current international literature that suggests girls engage in less MVPA and more ST during-school hours (large and medium effect size, respectively),[17 18] and no significant difference in LPA.[18] One such study among 380 children (aged 8-11years) from Vancouver, Canada, found that during-school (9am-3pm) boys and girls engaged in on average 63 mins.d^{-1} and 53 mins.d^{-1} of MVPA, 56 mins.d^{-1} and 54 mins.d^{-1} of LPA and 246 mins.d^{-1} and 260 mins.d^{-1} of ST, respectively.[18] These findings are largely comparable with the current study, although it would appear that this Australian sample engaged in more LPA in preference to ST, although this may be simply reflect the differing classification of the school day (9am-3:30pm) in the present study.

This article extends the current knowledge base by examining the gender-specific association of weight status on LPA, MVPA and ST throughout defined periods of the school day; and, is believed to be the first study of its type among Australian school children. No significant differences were observed between children who were within the healthy weight range and those with overweight/obesity for Before-school or After-school LPA, MVPA or ST participation in both the bivariate and multivariable analyses. However, the associations between During-school participation and weight status differed significantly among girls and girls. Compared to their peers with healthy weight, boys with overweight/obesity engaged in significantly less average counts.min^{-1} and girls with overweight/obesity engaged in approximately -12 mins.d^{-1} less LPA and -6 mins.d^{-1} less MVPA and +20 mins.d^{-1} more ST after adjustment for covariates. The observation that weight status was significantly associated with PA participation throughout the school day among children is supported by a large multi-national European study.[17] The ENERGY study (Belgium, Greece, Hungary, Netherlands, Switzerland) among 1,025 children (aged 10-12 years) with complete accelerometry data found weight status predicted MVPA but not ST participation.[17] It was found that children with overweight/obesity spent significantly less time (4% vs 5%, $p \leq 0.01$) within the school-day engaged in MVPA compared to children with healthy weight. A country-specific effect for the Netherlands was observed for ST, with children with overweight/obesity engaging in more ST (70% vs 66%, $p \leq 0.05$) compared to children with healthy weight. These findings support our observances of differences in during-school participation by weight status, although of note is the observance that European children engaged in very little amounts of MVPA during-school (16 ± 9 mins.d^{-1}) compared to the current Australian sample (41-63 mins.day^{-1}). Varying country-specific differences, including seasonal differences, may be driving this observation as well as the varying accelerometry data handling and inclusion criteria employed in both studies.

We found that children recorded less activity after-school than during-school, which is in contrast to the international notion that the 'After-school' period is a critical window for children's PA and can reflect up to 50% of PA engagement.[43] It is hypothesised that since children in the current study were sampled from communities that have been specifically identified as at-risk areas for chronic disease, the feasibility of after-school PA participation is realistically limited due to a variety of individual, environmental and psychosocial factors (e.g. costs, availability of transport to and from, parental-work commitments). For these communities, the school environment appears to be a critical setting for PA to be provided within school hours. Lessons learned from South Australian children (aged 10-13 years) [44] identified that the key barriers to after-school PA were safety for after-school active transport, distances to engage in PA opportunities and weather. Additionally, students identified perceived competence, enjoyment, being active with friends, school sport in preference to community sport due to distance, bullying, parental rules regarding participation and lack of time also impacted on after-school PA participation.[44] More research is therefore needed to identify the key facilitators and barriers to both during-school and after-school PA among children from disadvantaged communities to identify and implement possible solutions, particularly for girls.

Several limitations should be considered alongside the findings from this study, including assumptions underlying cross-sectional data. Firstly, the analyses sample emerged from a sub-sample of participants involved in the wider Healthy Together Victoria and Childhood Obesity study who were randomly assigned accelerometers due to the limited number available. Examination of this selection bias showed no significant difference between the included study sample and those excluded for insufficient wear, those excluded for lost/accelerometry error and those not given an accelerometer in mean age, gender distribution, SEIFA quintile or weight status. A significant differences was found for CALD background and participation/non-participation category, but this difference is likely to relate to the fact that 32 accelerometers were initialised incorrectly (set to 1-day instead of 7-day of monitoring) at one culturally and linguistically diverse primary school. However, the influence of non-participation bias can never be eliminated. Secondly, the utilisation of accelerometers involved many data-handling and management techniques which can directly influence the reported duration spent in intensities of PA[45] as they are not standardised.[46] The authors have opted for full-disclosure of all data handling and management techniques to increase the transparency of the achieved results. Specifically, we classified MVPA as ≥ 3 METs and used VM counts to classify activity intensity, as was done in the Romanzini equations.[33] Future research should look at the development of age-specific activity intensity cut-points using VM counts as there is evidence to suggest that energy expenditure varies by age and pubertal status.[47] Finally, the participants are drawn from communities selected for their high rates of chronic disease and levels of socioeconomic disadvantage,[20] and thus are not representative of the Victorian population but may reflect students whom are most-likely to be at risk.

Conclusion

Contrary to previous findings the during-school period constituted the greatest accumulation of MVPA for Grade 4 and Grade 6 children in the current sample. These findings highlight that among disadvantaged children, the school environment is a priority setting for interventions to promote PA at the expense of ST, especially among girls.

Author's contribution

Strugnell, Millar and Allender are all members of the executive committee overseeing the design, implementation and evaluation of the present study. Strugnell, Turner, Malakellis and Hayward were responsible for the collection, entry and cleaning of the data with Foster providing critical data management and analytic expertise of the accelerometry data. Strugnell led the development of the manuscript and all authors were involved in refining the paper and had final approval of the submitted and published versions.

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Competing interests

All authors affirm that they have no conflicts of interest and the funding agencies had no input to the design and conduct of the study.

Ethics approval

Prior to commencing this study ethical approvals from the Victorian Department of Education and Training (2013_002013), the Catholic Archdiocese of Melbourne, Sandhurst, Ballarat and Sale, and Deakin University's Human Research Ethics Committee (2013_095) were sought and granted.

Data sharing statement

No additional data are available

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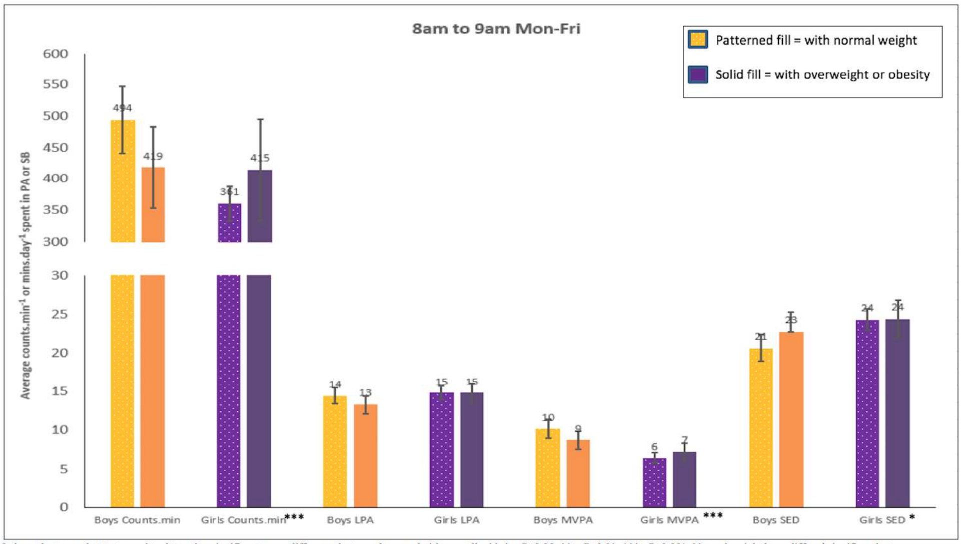
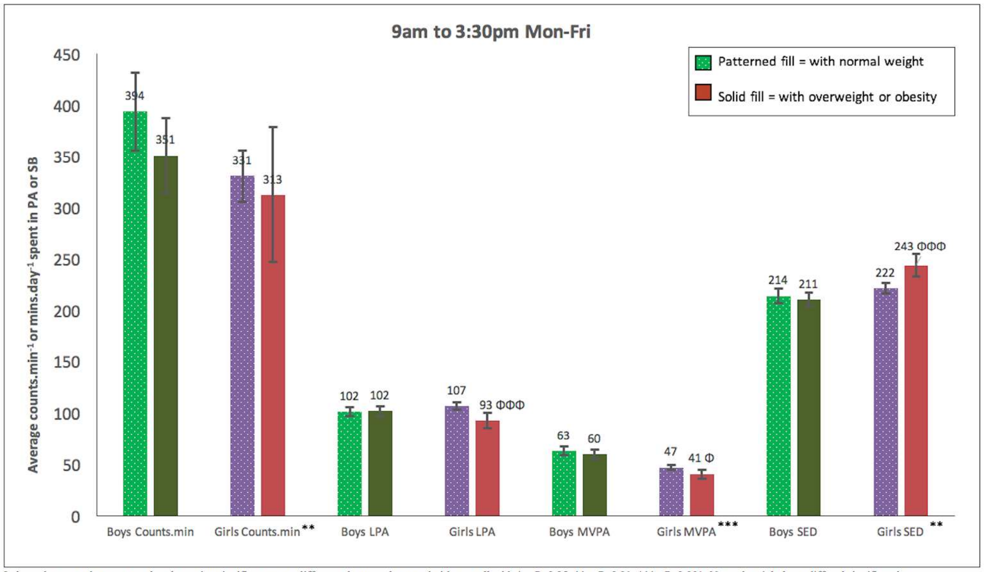
Figure 1a. Before-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) ^



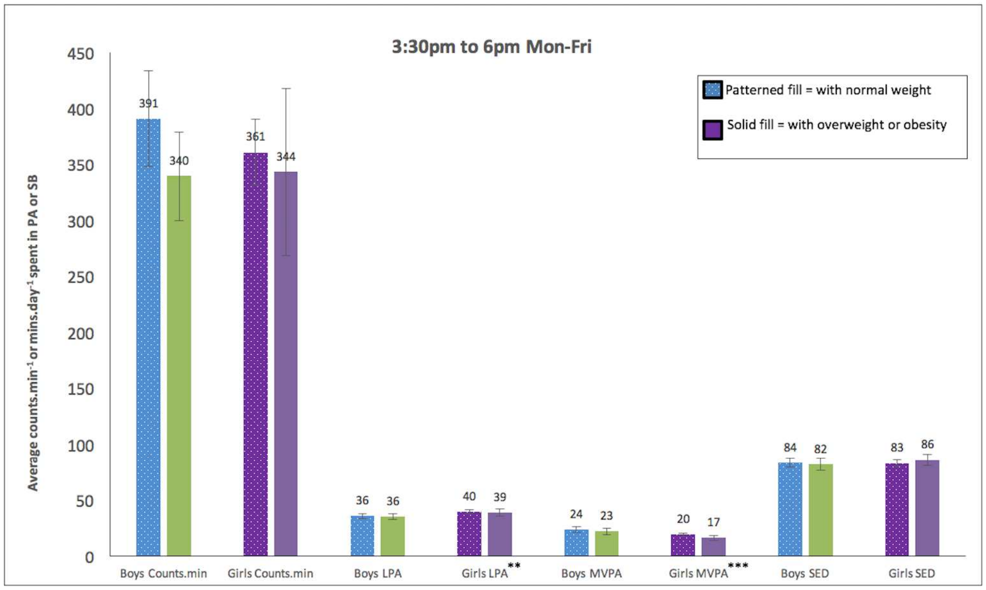
Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Normal weight boys differed significantly to overweight/obese overweight/obese boys with Φ = P≤0.05; Φ Φ Φ = P≤0.001; Normal weight girls differed significantly to overweight/obese overweight/obese overweight/obese girls Australian with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ^ = based on Greater than 600min.d-1 of monitoring over => 3 days; § = Normal weight category included underweight.

Figure 1b. During-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) ^



Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Normal weight boys differed significantly to overweight/obese overweight/obese boys with Φ= P≤0.05; ΦΦΦ = P≤0.001; Normal weight girls differed significantly to overweight/obese overweight/obese girls Australian with + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ^ = based on greater than 600min.d⁻¹ of monitoring over => 3 days; § = Normal weight category included underweight.

Figure 1c. After-school physical activity and sedentary behaviour participation by weight status and gender (mean and 95% Confidence Interval) ^



Independent-sample t-tests used to determine significant mean difference between boys and girls overall with * = P≤0.05; ** = P≤0.01; *** =P≤0.001; Boys with normal weight differed significantly to boys with overweight/obesity Φ= P≤0.05; ΦΦΦ = P≤0.001; Girls with normal weight differed significantly to girls with overweight/obesity + = P≤0.05; ++ = P≤0.01; +++ = P≤0.001); ^ = based on Greater than 600min.d^{-1} of monitoring over => 3 days; § = Normal weight category included underweight.

Appendix 1. Demographic characteristics of the accelerometry sample (participants) compared to non-participants for this study

	Study sample Participants met minimum wear-time criteria (≥ 600min.d^{-1} over ≥ 3 days **(N= 298)**	**Excluded – Insufficient wear** Did not meet wear-time criteria **(N= 73)**	**Excluded – Lost/error** Accelerometer was lost or damaged/ incorrectly initialized, failed to download **(N= 63)**	**Excluded- Not given accelerometer** No accelerometer issued or refused, only random sub-set offered **(N=422)**
Age	11.2 (9.21; 13.24)	11.3 (9.55; 13.56)	10.9 (9.54; 13.00)	11.2 (9.51; 13.11)
Gender	44% boys	53% boys	52% boys	47% boys
Ethnicity- Language Other Than English	13.0%	21.9%	46.0%	23.2%
SEIFA Quintile (Highest = 5th)	24.6%	20.6%	30.2%	23.9%
4th	27.7%	31.5%	19.0%	28.7%
3rd	11.9%	21.9%	27.0%	16.9%
2nd	30.5%	21.9%	19.0%	26.3%
Lowest = 1st	5.3%	4.1%	4.8%	4.3%
Weight Status (with overweight/ obesity)	30.9%	27.1%	33.3%	34.3%

A One-way ANOVA was conducted to examine if there was a significant difference in mean aged between the four accelerometry/non-participant type with no significant difference observed (F(3, 852) = 5.1, p=0.228). A series of Pearson's chi-square tests were conducted for categorical variables with no significant difference in gender distribution (X_3^2 = 3.3, p = 0.351), SEIFA quintile (X_{12}^2 = 16.7, p = 0.161), and weight status category observed between the four accelerometry/non-participant types (X_3^2 = 1.9, p = 0.604). However, a significant difference was detected for language spoken most commonly at home and the four accelerometry/non-participant types (X_3^2 = 36.1, p = 0.000).

Appendix 2. Contribution of the before-school, during-school and after-school period to overall (total) PA and SB participation

Gender and Weight status	Before-school (8am-9am)		During-school (9am-3:30pm)		After-school (3:30pm-6:00pm)		Combined (8am to 6:00pm)	
	LPA		**LPA**		**LPA**		**LPA**	
Boys Normal Weight (N = 82)	7.4	(6.97; 7.89)	52.5	(50.99; 53.90)	18.6	(17.72; 19.56)	78.5	(77.16; 79.86)
Boys Overweight/obese Overweight/obese (N= 48)	6.7	(6.27; 7.23)	52.2	(50.09; 54.24)	18.2	(17.05; 19.25)	77.1	(75.32; 78.81)
Girls Normal Weight (N= 124)	7.1	(6.72; 7.49)	51.2	(50.02; 52.37)	19.1	(18.47; 19.81)	77.4	(76.34; 78.54)
Girls Overweight/obese Overweight/obese (N=44)	7.8	7.18; 8.38)	48	(45.63; 50.38)	20.3	(18.89; 21.71)	76.1	(74.32; 77.86)
	MVPA		**MVPA**		**MVPA**		**MVPA**	
Boys Normal Weight (N = 82)	8.4	(7.48; 9.35)	52.0	(49.94; 54.07)	19.7	(18.15; 21.24)	80.1	(78.43; 81.82)
Boys Overweight/obese Overweight/obese (N= 48)	7.6	(6.77; 8.49)	53.4	(50.17; 54.69)	19.0	(17.29; 20.74)	79.1	(77.18; 80.96)
Girls Normal Weight (N= 124)	**6.8**	**(6.21; 7.47)****	50.1	(48.33; 51.90)	20.4	(19.26; 21.61)	77.4	(75.86; 78.92)
Girls Overweight/obese Overweight/obese (N=44)	8.7	(7.49; 9.96)	48.8	46.15; 51.40)	20.1	(18.20; 22.03)	77.6	(75.69; 79.54)
	SED		**SED**		**SED**		**SED**	
Boys Normal Weight (N = 82)	4.5	(4.14; 4.92)	**47.0**	**(45.29; 48.73)***	**18.3**	**(17.55; 19.06)***	78.5	(77.16; 79.86)
Boys Overweight/obese Overweight/obese (N= 48)	4.7	(4.21; 5.21)	44.1	(41.98; 46.28)	17.0	(15.97; 18.06)	77.1	(75.32; 78.81)
Girls Normal Weight (N= 124)	5.0	(4.74; 5.34)	46.2	(44.87; 47.55)	17.3	(16.68; 17.90)	77.4	(76.34; 78.54)
Girls Overweight/obese Overweight/obese (N=44)	4.8	(4.27; 5.34)	47.3	(45.61; 48.92)	16.8	(15.86; 17.79)	76.1	(74.32; 77.86)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,

		describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.