The Place of Physical Activity in the Time Budgets of 10- to 13-Year-Old Australian Children

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Background: Low physical activity has been associated with increased fatness and decreased fitness. This observational study aimed to describe the magnitude, composition, and time-distribution of moderate-to-vigorous physical activity (MVPA) in Australian children. Methods: A total of 1132 10 to 13-year-old schoolchildren completed a 24-h activity recall diary on 2 to 4 occasions. MVPA was defined as any activity requiring ≥3METs, including sport, play, active transport, chores, and other activities. Results: MVPA was higher in boys than girls (173 vs 140 min/day; \( P < .0001 \)), higher on nonschool days than school days (166 vs 143 min/day; \( P < .0001 \)), and decreased with age (9 min/day per year of age). MVPA consisted of structured sport (37%), active transport (26%), unstructured play (24%), and chores/miscellaneous activities (13%). Every hour of MVPA was associated with a reduction in screen time (26.5 min), non-screen-based sedentary pastimes (8 min), and sleep (5.5 min). The least active quartile of children were more likely to be girls (OR = 3.4), have higher screen time, and sleep more. From 4:00–6:30 PM on school days there were large differences in participation between high-active and low-active children. Conclusion: Findings suggest MVPA interventions should target girls, screen time and focus on the after-school period.

Keywords: use-of-time, adolescents, screen time

Rapid increases in children’s level of fatness over the last 3 decades\(^1\) and decreases in fitness\(^2\) have focused attention on children’s activity levels. Increasing fatness arises from an energy imbalance, which may be associated with decreases in energy expenditure. Decreases in fitness performance, especially in running tests, probably reflect both increasing fatness and a reduced training effect from lower levels of vigorous activity.\(^3\)

During adolescence there is a rapid decrease in physical activity and a peak in sedentary behavior.\(^4\)\(^-\)\(^6\) There are very few good data series on secular trends in adolescents’ moderate-to-vigorous physical activity (MVPA), mainly due to different methodologies yielding incommensurable results.\(^7\) Some recent studies have shown promising increases in physical activity, with Hardy and colleagues\(^8\) reporting increases in MVPA in Australian adolescents between 1997 and 2004 and Raustorp and Ludvigsson\(^9\) reporting increased pedometer steps on weekdays in Swedish children between 2000 and 2006. In contrast, however, some other activity snapshots suggest that MVPA is declining. Heath, Pratt, Warren, and Kann estimated that between 1984 and 1990, the percentage of US high school students participating in vigorous physical activity for 20 or more minutes per day on 3 or more days per week fell from 62% to 37%.\(^10\) In the US, enrolment in high school PE fell from 65% in 1984% to 52% in 1990,\(^10\) and again from 42% in 1991 to 28% in 2003.\(^11\) There have also been reports from Australia, the UK, and the US of consistent declines in children’s active (nonmotorized) transport, especially in relation to trips to school. Between 1985 and 1993, the average yearly distance walked by British children aged under 15 fell from 395 to 317 km, and the average distance ridden on bicycles fell from 61 to 45 km.\(^12\) US Department of Transportation data show that between 1977 and 1995 there was a 37% decline in the number of trips made by American children on foot or by bicycle.\(^13\)

There is stronger evidence in relation to increasing sedentariness both in children and in adults. Television viewing has doubled in Britain compared with the 1960s mainly due to increased market penetration of televisions.\(^14\) In the US, time spent watching television among adults has increased from 1.5 hours per day in 1965, to 2.1 hours in 1975 and 1985, to 2.3 hours in 1995,\(^15\) to 2.6 hours in 2007.\(^16\) Cohort studies suggest more dramatic secular increases in computer time among US adolescents, with girls computer use increasing from 8.8 to 11.1 hours/week and boys increasing from 10.4 to 15.2 hours/week between 1999 and 2004.\(^17\) It is possible that increased screen time (time spent in front of the television, video games console, computer monitor, or cinema screen) is associated with lower MVPA,\(^18\) although the literature is not consistent on this point.\(^19\)
Few studies have adopted a use of time approach to studying MVPA. Like all of us, children have 24 hours a day to fill with activities. They can spend this time in various ways, doing various mixes of activities at various times throughout the day. We refer to the way children choose, or are constrained, to use their time as a “time budget.” While many studies have attempted to quantify MVPA and to explore its correlates, very few have focused on the place of MVPA in children’s overall time budgets, detailing not only the magnitude and distribution, but also the composition and time-distribution of MVPA.20 There has also been little consideration of how high levels of MVPA are accommodated into the time budgets of active children.21 Children with high MVPA must structure their time budgets differently from those with low MVPA. What types of activities do high-MVPA children sacrifice or displace to be active? Are levels of activity and sedentariness (eg, television viewing) independent of one another (ie, can children have both high levels of activity and high levels of sedentary behavior), as has been previously suggested.22,23

Unlike activities such as television viewing, MVPA is relatively “impermeable,” in that it is very difficult to simultaneously perform certain other activities. While it is possible to, say, run and listen to music, a whole range of activities (study, chores, self-care) are difficult or impossible to perform concurrently with MVPA. Rather, for high levels of MVPA to be performed, some kind of displacement of other activity types is likely to occur. If and when displacement occurs, it may be selective. When children prioritize a particular activity category, it may displace functionally or structurally cognate activities (for example, active transport may displace motor-based transport, or television viewing may displace listening to music), or it may displace an elastic activity (certain activities are elastic in that the time of the day they take place and their overall duration are readily changed, for example television viewing). In contrast, some daily activities are relatively inelastic in that they must take place (eg, chores and self-care), and they may be time-locked, in the sense that they tend to occur at the same time each day (eg, bathing, eating). Activities time-locked into the same period of the day are natural competitors and tend to displace each other.

Use-of-time profiling has the potential to suggest points of leverage for interventions designed to increase MVPA. It can identify particular time-periods when low-activity children are especially inactive, specific activity categories in which they are deficient, activity pattern differences between subgroups with varying levels of MVPA, and alternative time-budget structures.

The aims of this study were to (1) describe the magnitude, distribution, composition and time-distribution of MVPA in 10 to 13 year old Australian children, in relation to sex, age, socioeconomic status (SES), and level of fatness; (2) examine how use of time profiles differed between high- and low-activity children; and (3) determine the characteristics of low active children, with a view to designing targeted interventions.

Methods

Participants

The participants in this study were 1132 children in grades 5 to 7 from 92 primary schools in South Australia. Schools were randomly selected from all primary schools in South Australia, excluding special schools and very remote schools, using a random number generator. The response rate was 69% for schools, and 92% for children within the chosen age group within each school. No data were available on children who declined to participate, but nonparticipating schools were not significantly different in School Card Register (a measure of the percentage of children who receive financial assistance from the government), geographical location (metro versus rural) or school size (number of students). Ethical approval was granted by the University of South Australia Human Research Ethics Committee and the South Australian Department of Education and Children’s Services. Written informed consent was obtained from the parents of all children involved. Children were classified as living in metropolitan or nonmetropolitan regions based on their residential postcode. The characteristics of the participants are shown in Table 1. They did not differ from the overall South Australian population of this age as regards mass, height, BMI, socioeconomic status, and proportion of metropolitan vs nonmetropolitan children.

A somewhat lower proportion of children in the sample (20.3%) than in the population (26%) attended nongovernment schools (P < .0001).

Measurements

Use of time data were collected between July 2002 and July 2003, using the Multimedia Activity Recall for Children and Adolescents (MARCA). This software asks children to recall their previous day’s activities from wake up to bed time in blocks of at least 5-min duration. Children may choose from lists of more than 250 activities, grouped into 7 categories. When they were doing 2 or more activities at the same time, children were asked to choose their main activity. For physical activity variables, children were asked to indicate whether their activity was light, medium or hard, assisted by cues based upon heart rate, rate of breathing, or ability to hold a conversation. Each listed activity is linked to an estimated energy cost.24

The MARCA has a same-day test-retest reliability of $r = 0.84$ to 0.92 for major outcome variables [MVPA, physical activity level (PAL) and screen time (the number of minutes spent watching television, playing videogames and using a computer]), and convergent validity with reference to accelerometry of $\rho = 0.45$ for PAL.25

The MARCA was administered in small groups in school computer laboratories during school time, overseen by a trained research assistant. Every child completed the MARCA on 2 to 4 occasions, at least one of which recalled a full day at school, and one a nonschool day (weekend or holiday). Children also
Table 1  Characteristics of the Participants in This Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys</th>
<th>Girls</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>582</td>
<td>550</td>
<td>1132</td>
</tr>
<tr>
<td>Age (years)</td>
<td>11.7 (0.7)</td>
<td>11.7 (0.7)</td>
<td>11.7 (0.6)</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>44.3 (10.8)</td>
<td>43.4 (9.3)</td>
<td>43.9 (10.1)</td>
</tr>
<tr>
<td>Stature (cm)</td>
<td>149.5 (7.3)</td>
<td>150.1 (7.7)</td>
<td>149.8 (7.5)</td>
</tr>
<tr>
<td>BMI (kg.m⁻²)</td>
<td>19.7 (3.7)</td>
<td>19.1 (3.1)</td>
<td>19.4 (3.4)</td>
</tr>
<tr>
<td>SEIFAb</td>
<td>998 (93)</td>
<td>991 (96)</td>
<td>994 (96)</td>
</tr>
<tr>
<td>Nonmetropolitan (%)</td>
<td>24.2</td>
<td>24.9</td>
<td>24.6c</td>
</tr>
<tr>
<td>Nongovernment schools</td>
<td>19.6</td>
<td>20.9</td>
<td>20.2d</td>
</tr>
</tbody>
</table>

There were no differences between boys and girls (P > .05) on any of the variables.

SEIFAs (Socio-Economic Indicators For Areas) are a series of indexes of socioeconomic status devised by the Australian Bureau of Statistics using a range of indicators such as educational and employment status. The index used here is the Index of Relative Disadvantage at the postal area level. The national average is 1000 and the SD is 100, and the average for the whole state is 982. Higher values indicate more advantaged areas.

27% of South Australians live in nonmetropolitan areas.

Across the whole state, 26% of primary school aged children attend nongovernment schools.

provided sociodemographic details, including date of birth and residential postcode. On the first occasion, children’s stature and mass were measured objectively according to the protocols of the International Society for the Advancement of Kinanthropometry.

**Data Treatment**

An overall estimate of daily energy expenditure (PAL, in METs) was calculated by multiplying the number of minutes allocated to each activity by the estimated activity energy expenditure, and dividing by the number of minutes in the day. Minutes of MVPA were calculated by summing the number of minutes participants reported being involved in activities requiring ≥ 3 METs, according to the MARCA compendium. These activities were divided into 4 subsets:

- structured sport [ie, activities with recognized rules, typically taking place in specialized spaces (ovals, courts, etc.)]
- active transport, including walking, cycling, riding scooters, and skateboards
- unstructured play, including playground games, playing with animals and younger children, and general “mucking around”
- chores and miscellaneous activities, such as general cleaning, laundry, work in the garden, and playing some musical instruments.

Screen time was calculated as the total time spent watching television, playing computer/video games, and using the computer. Sleep duration was calculated on the basis of reported sleep time and wake times, including intraday naps, and excluding the activity “lying awake in bed.”

Since there are substantial differences in school and nonschool activity patterns, and because children spend approximately 1 day in 2 in school, use of time variables were quantified as the average of the average of school and nonschool day values.

Children were categorized as normal weight (76% of the sample), overweight (18%) or obese (6%) using the classifications of Cole, Bellizzi, Flegal, and Dietz.

**Data Analysis**

Most time-use variables were highly skewed; therefore descriptive data have been expressed as medians. Where possible, Box-Cox transformation was used to normalize data (PAL, MVPA, sleep, and screen time), and normalization was confirmed using d’Agostino’s test. Box-Cox transformation was not possible for certain activity subsets (eg, time playing video games) because of the large number of 0 values. Age and socioeconomic status scores, based on the Australian Bureau of Statistics’ Socio-Economic Indicators For Areas (SEIFA), were normally distributed.

Linear regression was used to explore the associations between variables. Comparisons were made between boys and girls, children living in metropolitan and nonmetropolitan regions, between school days and nonschool days, between within-school and out-of-school activity, and between children in the most active quartile (‘high-active children’) versus the least active quartile (‘low-active children’). The strength of associations was assessed using either Pearson’s or Spearman’s correlation, and differences between means were tested using ANOVA or the Kruskal-Wallis, Mann-Whitney, and Wilcoxon signed rank tests, depending upon whether variables were normally or nonnormally distributed. Logistic regression was used to determine factors associated with being in the bottom quartile for MVPA (MVPA < 111 minutes/day).
To compare the kinds of activities engaged in by high- and low-active children, all activities mentioned by children in the most active and least active quartiles on school and nonschool days were listed, and their frequencies compared using chi-square analysis.

**Results**

**Descriptive Data**

**Magnitude of MVPA.** Children reported a median of 156 minutes/day of MVPA each day (Table 2). Boys had higher MVPA than girls (173 vs 140 minutes/day; \( P < .0001 \)), and MVPA was higher on nonschool days than on school days (165 vs 143 minutes/day; \( P < .0001 \)). MVPA decreased slightly with age (\( r = -0.08, P < .0001 \)) in the age range 10 to 13 years. This decrease was stronger in girls than in boys, and was more marked on school than on nonschool days. The overall rate of decrease was about 9 minutes/day per year of age. MVPA was not related to SEIFA (\( r = .02, P = .60 \)). MVPA was also unrelated to BMI category (\( P = .57 \)), for all children, and for boys and girls separately.

MVPA constituted 34 ± 13% of total daily energy expenditure. This figure was higher for boys (38%) than for girls (31%). MVPA constituted 48 ± 16% of waking energy expenditure, which was again higher for boys (53%) than for girls (44%). MVPA was therefore a major constituent of daily PAL, and correlated strongly with PAL (\( r = .82, P < .0001 \)). Every extra hour of MVPA increased PAL by about 9%.

The mean MVPA intensity (ie, energy expenditure in MVPA divided by min of MVPA) was 5.6 ± 1.3 METs. There were systematic variations in physical activity intensity. Boys reported a higher intensity than girls (5.8 vs 5.4 METs, \( P < .0001 \)), and intensity was greater on school days than on nonschool days (5.8 vs 5.4 METs, \( P < .0001 \)). Intensity was not related to BMI category, age, or total MVPA. There was a slight tendency for intensity to increase with SES (\( P = .05 \)), and metropolitan children reported higher intensity than nonmetropolitan children (5.7 vs 5.4 METs, \( P = .005 \)). It is also interesting to note that on school days the intersubject coefficient of variation (CV) for intensity (27%) was less than that on nonschool days (33%). The difference in variability was even more marked when total MVPA energy expenditures were compared for school days (CV = 55%) with nonschool days (CV = 70%).

**Distribution of MVPA Among Individuals.** MVPA showed strong positive skews (Table 3). These skews were stronger on nonschool days (IQ range = 159 minutes/day) than on school days (100 minutes/day). It is noteworthy that on nonschool days, 10% of children engaged in less than 25 minutes/day of MVPA.

**Components of MVPA.** The largest component of MVPA was structured sport (37%), followed by active transport (26%), play (24%) and chores/miscellaneous (13%). The absolute amount of time spent in different MVPA components was similar for boys and girls for active transport (median for boys 30 minutes/day, median for girls 33 minutes/day) and play (27 minutes/day vs 23 minutes/day). Boys spent less time on chores/
miscellaneous activities (8 vs 15 minutes/day), but much more time on structured sports (64 vs 34 minutes/day). Different levels of participation in structured sports therefore explain almost all of the difference between boys’ and girls’ MVPA.

The relative contribution of the structured sport and chores/miscellaneous components was fairly stable across different levels of overall MVPA. Active transport tended to make a relatively smaller contribution as overall MVPA increased. For children in the least active quartile, active transport constituted 30% of total MVPA; for children in the most active quartile active transport made up 24% of total MVPA.

**Time-Distribution of MVPA.** Figure 1 shows the percentage of active children at different times of the day for nonschool days (upper panel) and school days (lower panel). Data are shown for low-activity children (≤25 %ile; ≤98 minutes/day for school days, and ≤90 minutes/day for nonschool days) and high-activity children (>75 %ile; >198 minutes/day for school days, and >249 minutes/day for nonschool days), as well as for all children. On all days, high-activity children were more likely to be active earlier in the morning and later in the evening. Higher activity levels during recess, lunch, and in-school hours are also noticeable. On school days, there was also a strikingly different pattern between high-activity and low-activity children in the “critical window” period from the end of school to dinner (about 4:00 PM to 6:30 PM). Very few low-activity children were active in this period. By contrast, high-activity children were much more likely to be active in this period, prolonging the postschool spike.

MVPA on school days constituted slightly less than half (46%) of all MVPA. In-school-hours MVPA made up 56% of all school-day MVPA, the remaining 44% being accumulated before school and after school. Vigorous physical activity (VPA; ≥6 METs) constituted 36% of all MVPA time (39% for boys, 31% for girls; P < .0001). A little over half (54%) of all VPA took place on school days, of which 55% occurred in school hours.

**MVPA in the Overall Time Budget**

**MVPA and Screen Time.** Each hour of MVPA was associated with a reduction of 26.5 minutes in screen time (r = –0.30, P < .0001). The relationship was equally strong in boys (r = –0.41, a reduction of 35 minutes for

![Figure 1](image-url) — Percentage of children engaged in MVPA on nonschool days (upper panel) and school days (lower panel). Each panel shows values for the most active quartile (75 %ile or higher—top line), all children (middle line), and the least active quartile (25 %ile or lower—bottom line).
each hour of MVPA), and in girls ($r = -0.37$, a reduction of 32 min). For boys, most of the reduction in screen time (about 20 minutes) was due to less video game use; for girls, most of the reduction (22 minutes) was due to less television viewing.

**MVPA and Sleep.** There was an inverse relationship between MVPA and sleep ($r = -0.11, P < .0001$), which persisted when adjusted for age and sex. Every extra hour of MVPA was associated with a decline of about 5.5 minutes in sleep time (6 minutes for boys, and 3.5 minutes for girls).

**MVPA and Other Activities.** Every hour of MVPA was associated with a reduction of 8 minutes in nonscreen sedentary behavior (largely other media use, such as reading and listening to music, but also lying awake and talking on the phone), 3.5 minutes in self-care (hygiene, eating), and 3.5 minutes in social and family activities (eg, board games, church, playing musical instruments) (Figure 2).

These rates of reduction represent 8 to 11% reductions in the average time budgeted for these activity categories for each hour of MVPA, with the exception of sleep (1%) and self-care (3.5%). By way of example, children experiencing 0 to 60 minutes/day of MVPA spent a median of 274 minutes/day in screen time, slept on average 613 minutes/day and spent 81 minutes/day in other forms of sedentary pastimes. Children experiencing > 300 minutes/day of MVPA spent only 156 minutes/day in screen time, slept 599 minutes/day, and spent 45 minutes/day in nonscreen sedentary behavior.

**The Least Active Children**

Children in the bottom MVPA quartile (≤111 minutes/day MVPA) were classified as being low-active. Multivariate logistic regression was used to determine the factors associated with having low levels of MVPA. The results are shown in Table 4. Girls were 3.4 times more likely than boys to be low active. Higher levels of screen time ($P < .0001$) and sleep ($P = .0002$) were also significant predictors. SES, age, BMI category (normal-weight, overweight, obese), and region of residence (metropolitan vs nonmetropolitan) were not significant predictors.

The activities mentioned by high-MVPA (top quartile) and low-MVPA (bottom quartile) children were compared using chi-square analysis for school and nonschool days. The results are shown in Table 5. Low-MVPA

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**Figure 2** — Reduction in daily time devoted to other activities with every 1-hour increase in MVPA. “Sedentary” refers to sedentary pastimes other than screen time (eg, reading, listening to music). “Self-care” includes hygiene, meal preparation, and eating. “Social” includes activities such as board games, family get-togethers, and playing musical instruments. The bar charts show the median minutes per day devoted to screen time, nonscreen sedentary pastimes and self-care across MVPA bands.
Table 4 Results of a Multivariate Logistic Regression Determining Factors Associated With Being Low-Active (Bottom Quartile, ≤111 Min/Day of MVPA)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio (95% CIs)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex: female</td>
<td>3.4 (2.4–4.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Screen time: more</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sleep: more</td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td>SES: lower</td>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td>Age: younger</td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>BMI category: overweight</td>
<td>1.2 (0.8–1.9)</td>
<td>0.33</td>
</tr>
<tr>
<td>BMI category: obese</td>
<td>0.8 (0.4–1.8)</td>
<td>0.69</td>
</tr>
<tr>
<td>Region: nonmetropolitan</td>
<td>0.8 (0.6–1.2)</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Table 5 Comparison of the Frequency of Mentions of Activities by Low-MVPA (Bottom Quartile) and High-MVPA (Top Quartile) Children on School and Nonschool Days; Comparisons Were Made Using Chi-Square Analysis, and the Activities Are Listed in Order of the Significance of the Difference*

<table>
<thead>
<tr>
<th>School days</th>
<th>Nonschool days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-MVPA &gt; high MVPA</td>
<td>High-MVPA &gt; low-MVPA</td>
</tr>
<tr>
<td>hand-tennis</td>
<td>drama</td>
</tr>
<tr>
<td>sit and talk</td>
<td>mucking around</td>
</tr>
<tr>
<td>writing</td>
<td>Australian football</td>
</tr>
<tr>
<td>video games</td>
<td>running around</td>
</tr>
<tr>
<td>eating</td>
<td>walking</td>
</tr>
<tr>
<td>shopping</td>
<td>rough and tumble play</td>
</tr>
<tr>
<td>drawing</td>
<td>cricket</td>
</tr>
<tr>
<td>riding in a bus or car</td>
<td>soccer</td>
</tr>
<tr>
<td>talking on phone</td>
<td>chasey</td>
</tr>
<tr>
<td>sitting quietly</td>
<td>cycling</td>
</tr>
</tbody>
</table>

* All differences were significant at the $P < .001$ level.

children had a much higher frequency of mentions of sedentary pastimes, such as sitting and talking, writing, and video games. High-MVPA children were more likely to mention unstructured play, such as “mucking around,” and active transport (walking, cycling). The choices of high-active children also reflected sports typically popular among boys (football, soccer, cricket).

**Discussion**

This study explored the magnitude, characteristics and temporal patterning of MVPA using a use-of-time approach rarely used in physical activity research. Key findings were that every hour of MVPA was associated with a reduction in screen time (26.5 min), non-screen-based sedentary pastimes (8 min), and sleep (5.5 min). In addition, the least active quartile of children were more likely to be girls, have higher screen time, and sleep more. Between 4:00 PM and 6:30 PM on school days there were large differences in participation between high-active and low-active children, suggesting these may be key areas to target in physical activity interventions. Physical activity patterns were less variable on school days compared with nonschool days, suggesting that school acts as a ‘homogenizing regimen,’ and as such appears to be an important site for increasing MVPA in inactive children.

**Descriptive Data**

The magnitude and characteristics of MVPA found in this study were considerably higher than those generally reported elsewhere, largely due to methodological and classificatory differences. While many researchers define MVPA as any activity requiring ≥ 3 METs, most questionnaires focus on organized sport and free play, and ignore
the very significant contributions of active transport (26% of total MVPA) and miscellaneous activities (13%) found in this study. Myers et al surveyed most of the activities included as MVPA in this study, and found reasonably comparable levels of daily MVPA in American children of the same age (153 vs 173 min for boys; 110 vs 140 min for girls). It is also interesting to note that studies using accelerometry to estimate MVPA minutes report mean values that are closer to those observed in this study (for example, mean MVPA minutes of 166 min·d$^{-1}$ in a sample of Australian children and adolescents).

Using a use-of-time approach allowed us to distinguish between the various subcomponents of MVPA. Change in composition of MVPA was observed across different age groups within the sample. It is a common observation that MVPA decreases with age, at least after the peri-pubertal years. In this study, MVPA decreased by 9 minutes/day for every year of age. Almost all of the decrease (8 minutes/day per year of age) was due to a reduction in unstructured play, with sport, active transport and chores relatively unchanged across age groups. Myers et al noted a similar shift in activity components in 10- to 13-year-old children, with rapid and systematic declines in participation in free play, but inconsistent patterns in sports participation. These compositional differences may be important in designing interventions to increase MVPA: older children may respond better to interventions designed to maximize structured sports participation rather than free play or incidental activity.

Almost all studies have found, like this one, that boys are more active than girls. The differences appear to increase with age and plateau after puberty. Reported MVPA intensity showed systematic variation. Boys reported exercising more intensely than girls. While this may be a reporting bias, it is consistent with observations of the playing styles of boys and girls, with boys tending to be space-dominating and competitive, and girls space-economical and co-operative. Reported intensities were also greater on school days than on nonschool days. These differences are relevant when using only reported minutes of MVPA as a metric for energy expenditure, an approach which would result in a relative underestimation of energy expenditure on school days vs nonschool days and for boys vs girls of 7 to 8%.

MVPA was unrelated to BMI category in this study. Prima facie, one would expect higher levels of MVPA in leaner children. In this study, MVPA was associated with higher overall PALs, with each hour of MVPA increasing PAL by about 9%. This relationship was identical for boys and girls. If active children have a higher overall energy expenditure, and yet are not thinner, it would seem they make dietary adjustments. However, the literature is inconsistent concerning the relationship between MVPA and fatness. Many studies, though not all, have found associations between MVPA and fatness in children. However, like the current study, many of these studies are cross-sectional, therefore unable to determine causation. A meta-analysis of 50 studies using various metrics of physical activity and fatness showed a small

to moderate inverse correlation ($r = -0.16$). It seems likely that this relationship would be diluted by the subgroup of children who have matured relatively early, who have higher fat-free masses, and hence higher BMIs, who excel at sports, and hence are likely to be more active. For example, Andersen, et al found that Tanner-score adjusted BMI increased as vigorous activity increased in boys. It is also possible that there are stronger relationships between adiposity and vigorous, as opposed to MVPA. It is possible, for example, that while lean and overweight or obese children accumulate a similar number of minutes of MVPA, the composition of MVPA may vary. For example, lean children may accumulate more minutes of sport, and hence have a greater energy expenditure associated with MVPA.

Most studies have found very strong positive skews in children’s MVPA. Myers et al reported even larger interquartile ranges (112–170 min) than those found in this study (about 100 min). Consequently, MVPA should be reported as a median rather than as a mean.

**MVPA in the Overall Time Budget**

In this study, the inverse relationship between MVPA and screen time was strong and consistent: every hour of MVPA was associated with a reduction of about 30 minutes in screen time in both boys and girls, and across year groups. Other reports of relationships between MVPA and screen time have been more equivocal. While several other studies have also found inverse relationships, others have found no relationship. One study even found a positive relationship: more active children watched more television.

Despite the lack of consensus in the literature, it would be surprising if high MVPA were not associated with reduced screen time. High MVPA is possible only if time is taken from other activities. Screen time constitutes about 25% of waking time in children of this age, and is a likely “reservoir” from which time can be drawn. At certain times, such as the “critical window” after-school period, MVPA and screen time compete for children’s attention. Reductions in activity categories other than screen time were relatively small, including 5- to 10-min reductions per hour of MVPA in nonscreen sedentary pastimes and sleep.

In theory, greater MVPA could be associated with either increased or decreased sleep. Increased MVPA may make children more tired, and hence go to bed earlier or rise later. Alternatively, MVPA may displace other prioritized activities, which are then made up out of sleep time. In this study, MVPA had only a fairly weak relationship with sleep, with each hour of MVPA being associated with a reduction of about 5 min in sleep time.

**Low Active Children**

Sex, sleep and screen time were the only significant predictors of being low active, and together they accounted for only 11% of the overall variance. Unmeasured factors
are therefore a much stronger influence, and may include genetic factors, motor skills, psychosocial factors, environmental influences and family or cultural factors. It is interesting to note that the cut-off for the least active quartile of children in this sample was < 111 min/day, which considerably exceeds that Australian Department of Health and Aging guideline that children should accrue at least 60 min/day of MVPA. Spinks and colleagues similarly reported that only a small percentage (15%) of Australian children failed the physical activity component of the activity guidelines.

The current study suggests some points of leverage for interventions to increase MVPA in children of this age group:

- Interventions should particularly target girls, who are considerably less active than boys
- A key target time for interventions is the period from 4:00 PM to 6:30 PM on school days, where structured physical activities might be encouraged. These might include out-of-school hours care, sports team participation, or youth groups
- School synchronizes and equalizes MVPA regimens. On school days, the variability in minutes of MVPA, MVPA intensity and MVPA energy expenditure is much less than on school days. Differences between boys and girls are also somewhat diminished (median difference 35 minutes/day on nonschool days, and 20 minutes/day on school days). School therefore appears to be an important site for increasing MVPA in inactive children.

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