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Patterns of moderate and vigorous physical activity in obese and overweight compared with non-overweight children

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Abstract

Objective—We determined whether overweight and obese children performed less combined moderate and vigorous physical activity (MVPA), less vigorous physical activity (VPA) alone, and had distinct patterns of sustained MVPA or VPA compared with non-overweight children.

Methods—We monitored 106 children (aged 8 to 10 years) for 7 consecutive days using accelerometers. Differences in mean daily MVPA and VPA were assessed by comparing non-overweight (NOW) with overweight and obese (OW/OB) participants using descriptive statistics and regression analysis. We used an algorithm to identify periods of consecutive minutes where MVPA or VPA was continuous, called bouts. We then compared the bouts performed by NOW versus OW and OB participants with respect to the mean of the counts·minute⁻¹ for the minutes included in the bout, their mean length in minutes, and the number of MVPA bouts performed in sequence.

Results—The non-overweight group averaged 143 minutes of MVPA per day versus 120 minutes among the OW/OB (p=0.004). The OW/OB group had fewer MVPA bouts per day compared with the NOW (11.6 versus 17.6, p=0.012). Fewer VPA bouts were associated with greater body mass index z-score (p < 0.001). The NOW children had more intense body motion during MVPA bouts and performed a greater proportion of MVPA bouts in sequences of five or more consecutive bouts, compared with the OW/OB (p=0.05 and p=0.002, respectively).

Conclusions—In addition to performing less physical activity, we found that obese and overweight children had distinct patterns of MVPA and VPA bouts compared with non-overweight peers.

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Keywords

Accelerometer; child; obese; physical activity; moderate; vigorous

Introduction

The current epidemic of childhood obesity is, in part, related to low levels of physical activity and high levels of inactivity [1–3]. Studies have shown that, in children, most of their moderate and vigorous physical activity (MVPA) is performed in brief bursts, lasting less than 60 seconds, and occasionally in longer and continuous bouts [4,5]. Studies have also shown that performing less MVPA, on average, and performing a smaller proportion of MVPA in continuous bouts are more common among obese children and predict greater weight gain over time [6]. Despite the apparent importance of MVPA bouts, little is known about how variations in the characteristics of these bouts relate to obesity, such as the average intensity of body motion during bouts, their average duration, and how commonly they are performed in clusters or consecutively. In addition, these phenomena have not been well described among children belonging to minority groups living in urban communities despite higher levels of obesity and lower levels of MVPA reported in these groups [7–9]. If we attempt to treat obesity in these populations through improving physical activity, we must have a clear understanding of what specific components need to be altered, as well as the impact of changing specific aspects of physical activity on weight loss or weight maintenance. A more comprehensive understanding of the differences in physical activity patterns displayed by obese children compared with non-overweight peers is an important first step in this process.

The purpose of this study was to determine how physical activity levels and patterns differ among overweight and obese children compared with non-overweight peers using direct motion monitoring in a sample of 8 to 10-year-old Latino and African-American children living in an urban community. We conducted a cross-sectional analysis of motion and anthropometric data to identify differences in minutes of MVPA performed by non-overweight, overweight, and obese participants. These differences were examined separately with respect to total daily MVPA for all monitored days together, school days with and without physical education, and weekend days or school holidays. We also examined differences in minutes of daily vigorous physical activity (VPA) alone, as well as the relationship between the frequency of VPA bouts and weight status (using body mass index [BMI] z-score). Next we examined differences in MVPA bouts including the average number of bouts, the mean intensity of body motion during bouts, mean bout length, and patterns of consecutive bouts [10].

Methods

Participants

A sample of 113 boys and girls between 8 and 10 years of age were enrolled from a single community health center in New Haven, CT from September 2004 to June 2005. A total of 222 children were approached by their clinicians and 175 agreed to discuss the study with the on-site investigator. Children were excluded if they had neurological or orthopedic impairments, an acute illness that limited physical activity, attention deficit hyperactivity disorder, or other conduct disorder (n=35). Twenty-seven refused participation. Written informed consent from parents and assent from the children were obtained. Approval was obtained from the Human Investigation Committee at the Yale School of Medicine.

Demographics and anthropometrics

Parents reported sex, age, race and ethnicity. Weight was measured to the nearest 0.1 kg using a Seca digital scale (Hamburg, Germany). Height was measured to the nearest 0.1 cm using a stadiometer (Hamburg, Germany). Height and weight were measured twice and the values averaged. BMI ($\text{kg}\cdot\text{m}^{-2}$) was calculated from averaged height and weight. BMI percentile was determined using Centers for Disease Control and Prevention (CDC) growth charts. Children were categorized as non-overweight (NOW: BMI <85th percentile for sex and age), overweight (OW: BMI 85th percentile and <95th percentile for age and sex), or obese (OB: BMI 95th percentile for age and sex) [11]. The BMI z-score is a statistic representing the distance of each participant's BMI from the mean BMI of the US population by age and sex, and was also determined using CDC growth charts. Each child or parent reported the school days (weekdays from Monday to Friday that were not school holidays or parent reported school absences) when they participated in physical education classes. A New Haven public school calendar was used to verify school holidays.

Physical activity assessment

Participants were fitted with an *Actical* accelerometer (Minimitter, Bend, OR) [12]. The monitor was affixed to an elastic belt around the waist. Instructions were provided to wear the monitor all day and all night except for swimming and bathing for seven complete days (actual average length 7.8, range 5 to 13). Participants were excluded from the analysis if there were fewer than five days of complete data, defined as at least 12 hours of motion data between 7:00 am and 11:00 pm on school days, between 6:00 am and 11:00 pm on non-school days (Saturdays and Sundays or weekdays when school was not in session, or when children and parents reported being absent from school) [13]. Periods of 30 minutes or longer of consecutive counts=0 were considered non-wear time and excluded. A total of 106 subjects provided at least five monitored days that met criteria for inclusion in the analysis.

For 32 participants, monitoring epochs were 60 seconds. The remaining 74 participants were monitored using a 15-second epoch. New evidence suggesting that shorter epochs were more appropriate for detecting VPA in children emerged while the study was in progress. All motion data were converted to $\text{counts}\cdot\text{min}^{-1}$ for analysis. We used a two-step algorithm to identify sustained bouts of sedentary, light, moderate, and vigorous physical activity (described in detail elsewhere) [10]. Briefly, the first step identified transition points at the start and end of bouts of 3 minutes or longer with consecutive $\text{counts}\cdot\text{min}^{-1} = 0$ called "rest periods". The second step identified transition points between bouts of higher motion intensity ($\text{counts}\cdot\text{min}^{-1} > 0$). The algorithm then examined the coefficient of variation (CV) of the mean count for each minute and the 10 minutes before and after it, not including the rest periods. Each CV was compared with that of the last (most proximate) transition point in each subject's data. A difference of 20% in the two CV's was considered a transition between consecutive bouts. Thus, any minute for which the CV of the mean motion count for the minute and surrounding 20 minutes differed by 20% from the last transition point marked the start of a new bout. Using this method, each day was divided into a series of consecutive sedentary, light, moderate, and vigorous bouts. Parameters were chosen (including length of rest periods, number of minutes used to calculate the CV and percent difference in the CV's used to identify transitions between bouts) that provided the strongest possible agreement between classification of bouts using the algorithm and classification of bouts using the traditional method of assigning each $\text{counts}\cdot\text{min}^{-1}$ within the appropriate threshold values to an activity category (as sedentary, light, moderate, and vigorous) [10].

Each minute was given two motion count values, one for the 60-second epoch itself and another for the median count of the bout in which it belonged. Each minute was also assigned to two activity categories according to threshold counts derived from published

validation studies [12]. The appropriate application of these values was confirmed in a subset of participants in this study [14]. According to these established thresholds, sedentary epochs are those with a count of <100 ($<0.015 \text{ kcal} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$), light 100 to 900 (0.015 and $<0.05 \text{ kcal} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$), moderate 900 to 2 200 (0.05 and $<0.1 \text{ kcal} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$), and vigorous 2 200 ($0.1 \text{ kcal} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$).

Statistical analysis

Descriptive statistics (means and frequencies) were used to assess differences in demographics, anthropometric characteristics, and average motion counts $\cdot \text{min}^{-1}$ for non-overweight (NOW) compared with overweight (OW) and obese (OB) participants. Regression analysis was used to determine the association between weight group (NOW versus OW/OB) and mean daily MVPA minutes and mean daily MVPA bouts. In order to examine differences in mean daily MVPA minutes as a function of the type of day, mean amounts of MVPA performed on school days without physical education, school days with physical education classes, and non-school days were calculated. We next compared NOW with OW/OB participants with respect to the characteristics of MVPA bouts including their length in minutes, and mean bout motion counts.

The differences in bout characteristics between weight groups were tested using linear and logistic regression models. All regression models were adjusted for covariates including age (<9 , >9 years old), sex, and type of day (school day, school day with gym, or non-school day). Transitions between MVPA bouts were described by comparing the proportion of MVPA bouts that were preceded by a sedentary, light, or other MVPA bout comparing the OW and OB with NOW participants. We also examined the proportion of MVPA bouts that occurred in consecutive stretches longer than the median number of five bouts occurring in sequence, comparing OW and OB with NOW participants. Among the subset of participants monitored using a 15-second epoch, we determined the amount of daily VPA performed in short bursts (<60 seconds), intermediate bursts (60 to 119 seconds), and sustained bouts (>2 minutes). We used linear regression to assess the relationship between each type of VPA with BMI z-score. BMI z-score was chosen as the dependent variable rather than weight group to increase the power to detect an association given the small mean number of VPA minutes performed by participants in the sample. For all analyses we used Stata 10 (2006, StataCorp, College Station Texas, USA).

Results

There were no significant differences in demographic characteristics comparing OW/OB with NOW participants (Table I). The NOW group performed more mean daily MVPA minutes compared with the combined OW/OB group (142.9 minutes versus 119.7 minutes, regression coefficient= -86.95 , $\text{SE}=44.62$, $p=0.004$) and had a higher median number of daily MVPA bouts compared with the combined OW and OB group (17.6 versus 11.6 bouts, $p=0.012$) controlling for age, sex, and type of day (Table II). The differences in hourly MVPA minutes between weight groups varied according to the type of day (school day without physical education, school day with physical education, and non-school days) (Figure 1). Differences in mean daily MVPA minutes between weight groups were largest on school days with physical education classes (school with gym days) (146.8 versus 119.9, difference= 26.9 , $p=0.086$) and smallest on non-school days (140.9 versus 120.3, difference= 20.6 , $p=0.159$) although these differences were not statistically significant (Table II).

There was a statistically significant difference in mean motion counts per bout with the NOW group having higher mean motion counts during MVPA bouts compared with the combined OW/OB group (86.95 [$\text{SE}=44.62$], $p=0.05$) in regression analysis that adjusted for

sex, age, and type of day (Table III). The adjusted difference of 0.19 (SE=0.20) in mean length of MVPA intervals between weight groups, was not statistically significant ($p=0.34$).

There were differences in transitions between consecutive bouts comparing the NOW group with the combined OW/OB group (Table IV). For example, pairing of consecutive MVPA bouts (moving from one MVPA bout immediately to another MVPA bout of slightly different intensity) was more common among the NOW group compared with OW/OB group (62% [4 412 paired MVPA bouts/7 171 total MVPA bouts] versus 56% [3 673 paired/6 593 total]). Additionally, participants in the OW/OB group more commonly paired a MVPA bout with a light (OR 1.26, $p=0.009$) or sedentary (OR 1.80, $p<0.001$) bout compared with those in the NOW group. The NOW group more often had five or more consecutive MVPA bouts grouped together in time; 48% of all MVPA bouts were found in sequence with at least four other MVPA bouts (3 433 MVPA bouts in series of five or more bouts of 7 171 total bouts) compared with just 39% (2 590 bouts in series/6 593 total bouts) for the OW/OB group ($p=0.002$).

Among the 74 participants monitored with a 15-second epoch, the average minutes of VPA per day was 33 in the NOW group, and 23.7 in the OW/OB group. The number of VPA minutes performed as short bursts (29% and 37% of all daily VPA in the NOW and OW/OB groups, respectively) was not significantly associated with BMI z-score in regression analysis (Coefficient=-1.918, SE=2.073, $p=0.36$). The number of VPA minutes performed as sustained bouts (44% to 30% of all VPA) was significantly associated with lower BMI z-score (Coefficient=-18.575, SE=5.286, $p < 0.009$) (Table V).

Discussion

In this study there were significant differences in patterns of how overweight and obese children performed MVPA compared with their non-overweight peers. Although the observed difference in daily MVPA among OW/OB children could occur in many ways, our findings indicate that there are certain patterns of MVPA that are more characteristic of children in these weight groups. Specifically, those in the OW and OB groups, on average, performed fewer bouts of MVPA, performed a smaller proportion of MVPA bouts in consecutive clusters, and had bouts with lower mean motion counts. Although other studies have demonstrated a statistically significant difference in the average number of MVPA bouts performed as a function of weight group, none have described differences in bout characteristics. The findings of this study suggest that differences in patterns of MVPA between weight groups appear to be as prominent as differences in their total physical activity levels. When we examined patterns of VPA alone, we found that in the OW and OB groups, sustained VPA bouts made up a smaller proportion of the total daily VPA minutes performed. In addition, a greater number of VPA bouts was significantly associated with lower BMI z-score, whereas, more minutes of short bursts (<60 seconds) of VPA was not. Thus, assessing the characteristics of MVPA and VPA bouts might provide important insights into the connection between physical activity and obesity in children.

Our findings provide further evidence that children tend to integrate MVPA into their daily routines unlike many adults who tend to perform discrete periods of intense body motion required by work or recreational pursuits. Children in this study performed MVPA during each hour of the day with a spike in activity during afternoon hours (depicted in Figure 1), paired at least a third of MVPA bouts with light or sedentary bouts, and performed most of their VPA in periods lasting less than two minutes. The disorganized nature of children's physical activity makes it challenging to determine how best to assess changes in physical activity levels, to design interventions aimed at increasing MVPA levels, and to assess the efficacy of interventions with respect to sustained improvements of MVPA levels. This

study, and others, demonstrates the importance of using direct motion monitoring to identify deficits in MVPA levels and the patterns of MVPA that influence weight management. Applying the methods used in this analysis to intervention studies might provide a better understanding of why some physical activity interventions have shown mixed results with respect to their efficacy [15–17]. If, for example, intervention programs fail to target MVPA in particular, or do not promote an increase in sustained MVPA bouts, their efficacy in improving MVPA levels may be limited. In addition, a failure to alter these fundamental patterns of MVPA might explain, in part, why short-term gains in physical activity levels often fail to translate into sustainable lifestyle changes that mitigate weight gain over the long-term [15–18].

Several studies have demonstrated that children who perform more VPA tend to gain less weight over time and that VPA is the component of physical activity that appears most strongly associated with measures of adiposity [19,20]. In this study the VPA bouts made up a greater proportion of total daily VPA minutes among those in the NOW group (15%) compared with those in the OW/OB group (8%). In addition, a greater number of VPA bouts were associated with lower BMI z-score suggesting that those in the OW/OB group had a tendency to perform fewer VPA bouts. One possible explanation for this observed difference is poor physical conditioning [21]. Studies have shown that children with less MVPA and VPA also tend to be less fit, and that less physically fit children have a larger fat mass and gain more fat over time [22–24]. In addition, OW/OB children may exhibit a behavioral preference for sedentary or light activities and non-sustained VPA [25,26]. Applying this type of analysis to physical activity intervention studies might provide clues as to which approaches (i.e., a focus on improving conditioning or a focus on building self-confidence and interest in physical activity) result in changes in VPA patterns in the short- and long-term.

It is also important to note that we found variation among individual children within each group with respect to how they performed MVPA over the course of the day. For example, 37% of OW/OB children had more than the median number of MVPA bouts and 39% had longer than average strings of consecutive MVPA bouts. Thus the association between physical activity patterns and body fatness was variable among individual participants. It will be important to understand how these variations in physical activity levels and patterns among overweight and obese children relate to their response to interventions aimed at increasing physical activity levels and attenuating weight gain. For example, do overweight children who tend to perform more MVPA and more MVPA bouts have a better response to efforts aimed at increasing their physical activity compared with other overweight children who perform less MVPA? A better understanding of how variations in MVPA patterns influence an individual's response to intervention might help identify those children most likely to benefit from these efforts.

Despite the focus on urban dwelling Latino and to a lesser extent African-American children in this study, we found that the mean numbers of MVPA minutes per day (approximately 130) were higher than at least 75% of the mostly Caucasian participants of a similar age (7 to 9 years old) in a study by Pate et al., conducted in 1997 [27]. In addition the number of VPA minutes per day (approximately 30) in our sample was also higher than 95% of those same subjects. A study of school-aged children conducted by Trost et al. showed that those in the 1st to 3rd grades performed approximately 200 minutes of MVPA per day, whereas, children in the 4th to 6th grade performed an average of approximately 120 minutes [28]. In addition, Treuth et al. reported an average of approximately 100 minutes of MVPA per day among 8 and 9-year-old African-American girls [29]. Thus, we found no evidence of a relative deficit in MVPA level among participants in this studies compared with others [30].

Our approach to analysis of motion data allowed us to describe distinct patterns of physical activity among OW/OB children compared with NOW peers not found in previous studies. However, there are some limitations in this approach that should be considered. First, this algorithm is a statistical approach for identifying patterns of body motion. In order to describe these patterns a compromise had to be made between the degree of consistency of physical activity intensity within a given bout (or between transitions) and the length of bouts. The results of this compromise were compared with traditional bout identification using consecutive minutes of sedentary, light, moderate, or vigorous physical activity [10]. The results have not been validated using direct observation of physical activity that might identify the discrete behaviors captured by this algorithm both in field and laboratory settings. However, in previous analysis, the patterns of bouts and transitions identified with the algorithm were clearly associated with overall physical activity levels [10]. In addition, the algorithm identified new aspects of activity patterns obscured by simple sums and averages of motion counts and even previous analyses of long bouts of preset length.

It is also important to consider that participants in this study were those who volunteered to participate among patients who were seen for any type of healthcare visit in a single community health center. Several families refused to participate and several left the clinic before they could be approached for enrollment. This method of selection might have introduced bias by excluding non-overweight, overweight, or obese participants with physical activity levels or patterns that would have been different from the patterns of participants. In addition, this study was not designed to quantify the impact of patterns of physical activity, such as the number and patterns of MVPA bouts, on the activity energy expenditure (AEE) of individuals or groups of children. It is also important to consider that due to the cross-sectional design of this study we cannot determine the cause and effect relationship between physical activity and weight gain. Despite these considerations, these findings have important implications for how physical activity should be assessed and how deficits in physical activity levels should be interpreted among overweight and obese children. Specifically, applying the method of analysis of motion data used in this study might inform needed improvements in the design and evaluation of interventions aimed at improving physical activity levels and attenuating obesity in children.

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Abbreviations

BMI	Body mass index
SE	standard error
MVPA	moderate and vigorous physical activity
VPA	vigorous physical activity
CDC	Centers for Disease Control and Prevention (Clinical and Translational Science Award)

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Figure 1.

Hour-by-hour trends in moderate and vigorous physical activity (MVPA) minutes are shown according to the type of day including school days without physical education, school days with physical education, and non-school days. Two trend lines are shown one depicting average MVPA minutes in the Non-Overweight Group (NOW) and a second showing average MVPA minutes in the Overweight/Obese Group (OW/OB).

Table 1

Participant characteristics.*

	NOW	OW/OB	Total
<i>N</i> (%)	50 (47)	56 (53)	106
<i>Age: years (sd)</i>	9.3 (0.9)	9.6 (0.9)	9.4 (0.9)
Female: <i>n</i> (%)	30 (60)	29 (52)	59 (56)
BMI: kg/m ² (SD) ‡	16.8 (1.4)	23.8 (3.9)	20.5 (4.6)
Percentile (SD)	50.6 (21.2)	94.9 (3.7)	74.0 (26.7)
Race/Ethnicity <i>n</i> (%)			
Black	5 (10%)	8 (14%)	13 (12%)
Latino	38 (76%)	43 (77%)	81 (76%)
White	1 (2%)	4 (7%)	5 (5%)
Multi-ethnic	5 (10%)	1 (2%)	6 (6%)
Other	1 (2%)	0 (0%)	1 (1%)
Insurance <i>n</i> (%)			
Medicaid	38 (76%)	47 (84%)	85 (80%)
Uninsured	6 (12%)	3 (5%)	9 (9%)
Private	6 (12%)	6 (11%)	12 (11%)
Days and hours per day monitored			
Days: Median (range)	7.7 (5–13)	7.8 (5–12)	7.8 (5–13)
Hours: Median (range)	14.4 (12.3–16.7)	14.4 (12.6–15.4)	14.4 (12.3–16.7)

* This table compares participant characteristics among non-overweight children (NOW) and those who were overweight or obese (OW/OB). There were no statistically significant differences between weight groups with respect to age, sex, race/ethnicity, insurance type, days monitored, or hours per day of motion.

‡ Differences in body mass index (BMI) and BMI percentile were significant ($P > 0.001$). There were 38 obese participants (16 female and 22 male) and 22 overweight participants (15 female and 7 male).

Table II

Total Moderate and Vigorous Physical Activity (MVPA) minutes and bouts according to weight groups: Non-overweight (NOW) compared with Overweight and Obese (OW/OB) ^{*}.

Mean (SD) daily MVPA minutes and mean percent (SD) of total minutes for each type of day					
Type of day	NOW n=50		OW/OB n=56		P-value
	Total MVPA Minutes (SD)	Percent Mean % (SD)	Total MVPA Minutes (SD)	Percent Mean % (SD)	
School	140.9 (119.0)	17.1 (13.9)	119.0 (129.5)	13.9 (15.4)	0.047
School with gym	146.8 (119.9)	16.8 (13.4)	119.9 (132.5)	13.4 (15.0)	0.086
No school	140.9 (120.3)	16.9 (13.9)	120.3 (130.2)	13.9 (15.4)	0.159
All	142.9 (119.7)	16.9 (13.8)	119.7 (130.7)	13.8 (15.3)	0.004
Median number (range) of daily MVPA bouts and total daily bouts					
	NOW		OW/OB		P-value
	Median Number (range)		Median Number (range)		
MVPA bouts	17.6 (3.0–41.0)		11.6 (3.9–34.5)		0.012
Total bouts	111.9 (29.1–131.9)		110.3 (73.4–134.4)		0.642

^{*} Differences in moderate and vigorous physical activity (MVPA) minutes on separate day types are adjusted for age (< 9, > 9) and sex. Differences in MVPA intervals and all bouts are adjusted for age (< 9, > 9), sex, and type of day (school, gym, non-school).

Table III

Mean motion counts for Moderate and Vigorous Physical Activity (MVPA) bouts and average bout length in minutes for each weight group: Non-Overweight group (NOW) compared with Overweight and Obese group (OW/OB)*.

<u>Median (range) and mean (SD) motion counts for moderate and vigorous bouts</u>									
Type of bout	NOW n=50			OW/OB n= 56			Adjusted association between mean count (MVPA bouts) and weight group		
	Median (range)	Mean (SD)	Mean (SD)	Median (range)	Mean (SD)	Mean (SD)	Adjusted coefficient (SE)	P-value	
Moderate	1 270 (900–2 200)	1 350 (344)	1 242 (900–2 200)	1 331 (341)					
Vigorous	2 932 (2 200–14 587)	3 379 (1 357)	2 832 (2 200–11 145)	3 195 (1 194)			86.95 (44.62)	p=0.05	

<u>Median (range) and mean (SD) bout length (in minutes) for moderate and vigorous bouts</u>									
Type of bout	NOW			OW/OB			Adjusted association between bout length (MVPA bouts) and weight group		
	Median (range)	Mean (SD)	Mean (SD)	Median (range)	Mean (SD)	Mean (SD)	Adjusted coefficient (SE)	P-value	
Moderate	5 (1–67)	7.0 (6.3)	5 (1–57)	7.1 (6.3)					
Vigorous	4 (1–58)	5.4 (5.0)	4 (1–43)	5.7 (5.1)			0.19 (0.20)	p=0.34	

* For the Non-Overweight group (NOW) and the Overweight/Obese Group (OW/OB) the mean bout motion counts and mean bout lengths are presented separately for moderate physical activity bouts and vigorous physical activity bouts.

† The difference between the group mean values are presented for combined moderate and vigorous physical activity (MVPA) bouts for both motion count and bout length (in minutes). These differences are adjusted for age (< 9, >9), sex, and type of day (school, gym, non-school).

Table IV

Transitions from Moderate and Vigorous Physical Activity (MVPA) bouts to bouts of equal or lower motion intensity: Non-Overweight (NOW) compared with Overweight and Obese group (OW/OB).

Proportion (n) of MVPA bout pairings with bouts of similar or lower intensity for each weight group				
			Adjusted odds of bout pairing as a function of weight group	
	NOW n=50 Percent (n)	OW/OB n=56 Percent (n)	OR*	P-value
MVPA to sedentary	4.3% (311)	6.5% (430)	1.796	>0.001
MVPA to light	34.1% (2 448)	37.8% (2 490)	1.262	0.009
MVPA to MVPA	61.5% (4 412)	55.7% (3 673)	Reference	

* Odds Ratios for pairing of a moderate or vigorous physical activity (MVPA) bout with a bout of lower motion intensity were adjusted for age (< 9, >9), sex, and type of day (school, gym, non-school). A pairing of two MVPA bouts was the reference used in the logistic regression model.

Table V

Mean daily VPA minutes: Short burst, intermediate, and sustained bouts: Comparing the Non-Overweight (NOW) with the Overweight and Obese (OW/OB) Group ^{*}.

	NOW	OW/OB
N	30	44
Female: n (%)	19 (63)	22 (50)
Age: Mean years (SD)	9.3 (1.0)	9.5 (0.8)
BMI z-score: Mean (SD)	0.1 (0.6)	1.9 (0.4)
Short burst VPA: Mean minutes•day ⁻¹ (SD) [†]	9.7 (4.4)	8.7 (4.4)
Intermediate VPA: Mean minutes•day ⁻¹ (SD)	16.4 (9.5)	13.4 (8.1)
Sustained bouts VPA: Mean minutes•day ⁻¹ (SD) [‡]	14.6 (15.1)	7.2 (7.7)
Total VPA: Mean minutes•day ⁻¹ (SD)	33.0 (25.0)	23.7 (16.8)

^{*} Analysis includes only the subset of subjects (n=74) who had an accelerometer sampling interval (epoch) of 15 seconds.

[†] Daily minutes of vigorous physical activity (VPA) performed in *short bursts* (<60 seconds) or in *intermediate* lengths (60 and <2 minutes) were not associated with BMI z-score (p=0.36).

[‡] A greater number of average daily minutes of VPA performed in *sustained bouts* (2 minutes) was associated with lower BMI z-score (p=0.009), adjusting for age, sex, and type of day. Total VPA minutes•day⁻¹ is not the sum of the first three columns as 60-second periods where activity is less than vigorous are included in some VPA bouts.