

Measuring the Daily Activity of Lying Down, Sitting, Standing and Stepping of Obese Children Using the ActivPAL™ Activity Monitor

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Abstract

This study describes the patterns of objectively measured sitting, standing and stepping in obese children using the activPAL™ and highlights possible differences in sedentary levels and patterns during weekdays and weekends. Sixty-five obese children, aged 9–11 years, were recruited from primary schools in Terengganu, Malaysia. Sitting, standing and stepping were objectively measured using an activPAL™ accelerometer over a period of 4–7 days. Obese children spent an average of 69.6% of their day sitting/lying, 19.1% standing and 11.3% stepping. Weekdays and weekends differed significantly in total time spent sitting/lying, standing, stepping, step count, number of sedentary bouts and length of sedentary bouts ($p < 0.05$, respectively). Obese children spent a large proportion of their time sedentarily, and they spent more time sedentarily during weekends compared with weekdays. This study on sedentary behaviour patterns presents valuable information for designing and implementing strategies to decrease sedentary time among obese children, particularly during weekends.

Introduction

Childhood obesity is one of the major global health problems and has become a major concern to many health practitioners. In Malaysia, an apparent trend for a steady rise in the prevalence of childhood obesity has been noted in recent years. A study conducted in 2010–11 by South East Asia Nutrition Survey reported 9.8% of the Malaysian children aged 7–12 years old were classed as overweight and 11.8% were obese [1].

A large variety and number of determinants have been identified for the development of obesity in childhood, such as genes, dietary patterns, low levels of physical activity and excessive hours of screen time [2]. Sedentary behaviour refers to any waking behaviour characterized by an energy expenditure 1.5 metabolic equivalents while in sitting or reclining posture [3]. Wafa et al. (2011) reported that obese Malaysian children had high levels of sedentary behaviour: 12 h per day [4]. Malaysian children were also found to spend almost half of their sedentary time on screen-related activities including watching television, playing video games and using the computer [5]. A longitudinal study reported that time spent in sedentary activity is associated with increase in body mass index (BMI) between ages 9 and 15 years [6]. Furthermore, a previous study reported that frequent break in sedentary time and short bouts of sedentary behaviour are independently associated with markers of cardio metabolic risk in children [7].

Although studies have been conducted among Malaysian children, there is still a lack of information regarding physical activity levels and sedentary behaviours among obese children in Malaysia. A few studies have used objective measures such as accelerometer and pedometers to examine levels of physical activity in obese children [4, 5]. However, little is known about the amount of time children spend lying down, sitting, standing and stepping. Recently, the activPAL™ activity monitor has shown to be a valid measurement tool for assessing time spent sitting/lying, standing and walking, sit-to-stand and stand-to-sit transition counts (also known as sedentary bouts) and step counts and has become the method of choice to measure sedentary behaviours in children [8]. However, no studies using the activPAL™ have been conducted in Malaysia. Thus, the objective of this study was to objectively quantify obese children's

daily activity of lying down, sitting, standing and stepping using the activPAL™ activity monitor. The secondary purpose was to highlight possible differences in these behaviours between weekdays and weekends.

Methodology

Participants

The study was conducted at the Universiti Sultan Zainal Abidin (UniSZA), Terengganu. The schools were randomly selected across one large city in Terengganu, Malaysia. For entry into the study, children aged 9–11 years had to be obese [BMI > ≥ 2 SD relative to World Health Organization (WHO) 2007 Growth Reference]. Children were excluded if they had a serious comorbidity requiring treatment. Children were recruited from their primary schools after BMI screening conducted by one of the re-searchers (N.N.A.). Ethical approval was obtained from the UniSZA Human Research Ethics Committee (UniSZA.N/1/628-1 (28)), and parental consent and child assent were obtained before data collection.

Anthropometric measurements

Height was measured using portable stadiometer (Seca 213) to the nearest 0.1 cm, while weight was measured using the digital weight scale (Seca Robusta 813) to the nearest 0.1 kg. BMI and BMI z-score were calculated using the WHO AntroPlus software version 1.0.4. Only children classified as obese (≥ 2 SD) were included in this study.

ActivPAL™ physical activity monitor

Participants were then instructed to wear the activPAL™ activity monitor. ActivPAL™ activity monitor was a reliable and valid device to measure posture and ambulatory movements [8] as well as posture and activity in children [9]. Furthermore, the device has a high degree of accuracy in both slow and normal walking against video observation [8]. The activity monitor has been recommended to be used to measure sedentary levels, as it gives a direct estimate of body inclination, which does not rely on thresholds or cut-points [10]. The activity monitor was attached on the midpoint of the anterior aspect of the thigh using a double-sided hydrogel adhesive pad (PALstickie™) and covered with an elastic tube bandage to ensure that the device stayed in place.

They were instructed to wear the device for 7 days (including sleep time), and only to remove it during bathing, swimming or any water-related activities, as the device was not waterproof. activPAL™ provides two types of information: (i) steps and activity counts and (ii) inclinometer information (i.e. posture) [11]. Number of steps was used to determine physical activity, while inclinometer information was used to determine posture.

Dataprocessing

After 7 days, data from activPAL™ was downloaded to a computer via a USB interface. The data down-loaded were assessed using activPAL™ software (ActivPAL™ Professional version 7.1.18) and then exported to Microsoft Excel 2013 format file. An event file was created using the activPAL™ software. The event file displays the time spent in each posture. The event file coded '0' as sedentary, '1' as standing and '2' as stepping. Every change from code 0 to code 1 or 2 was considered as transition from sitting/lying to upright position. Meanwhile, times spent in these postures as provided in the event file were used to determine how long a participant was sitting (code 0).

Participant data were included in the analysis if they provided at least 600 min of data during waking hours on at least three weekdays and on at least one weekend [12]. For the purpose of this study, waking hours were defined as 6 am to 11 pm. Total sedentary hours (sitting/lying), standing and stepping over the waking hours period were summed directly from the activPAL™ output and averaged to get the mean time. Sedentary behaviours were determined as the total amount of time spent sitting/lying. A sedentary bout was defined as the times when the respondents were sedentary or the transition from standing to sitting/lying. The total number of sedentary bouts and the average length of a sedentary bout were then calculated.

Statistical analysis

During the data entry, the variables were checked to detect any error and missing data. Then data exploration was done for descriptive statistics for all variables. Normal distribution was tested for the numerical variables. The mean and standard deviation were calculated for numerical variables. With regard to the categorical variables,

frequency of observation and percentages were obtained. A paired t-test was applied to compare the difference of two means. All the variables were tested for normality and were normally distributed. The analysis was considered significant at a p-value <0.05. All data were analysed using Statistical Package for Social Science Version 20.0.

Results

Of the 204 subjects who were eligible and agreed to participate in this study, only 101 children attended for data collection. However, 36 subjects were excluded as data points were missing owing to activPAL™ monitor failure (n = 4), poor compliance with the activPAL™ protocol (n = 30) and monitors were lost (n = 2). Therefore, only 65 participants provided valid activPAL™ data and so were entered into analyses.

Participants' characteristics for the remaining 65 participants are shown in Table 1. All the participants were obese Malay children consisting of 39 boys and 26 girls. The mean age of the participants was 10.1 years with BMI 26.8 kg/m². Table 1 shows the mean total hours spent per waking day: sitting/ lying = 11.8 h, standing = 3.3 h, stepping = 1.9 h and number of steps per day = 8782 steps. Girls stood for a mean of 3.4 h and sat/lay for a mean of 11.8 h and achieved a mean of 7826 steps a day. On the other hand, boys stood on average for a mean of 3.1 h, sat/lay for a mean of 11.8 h and achieved a mean of 9420 steps a day.

During weekdays, obese children spent 68.4% of their waking hours sitting/lying, 19.9% standing and 11.7% stepping. Meanwhile, during weekends, they spent 72.7% of their waking hours sitting/lying, 16.9% standing and 10.4% stepping. The result indicates that these children spent 47 min more being sedentary during weekends than weekdays (Fig 1).

Significant differences were found in total time spent sitting/lying, standing and stepping and average daily step count, number of sedentary bouts and the average length of a sedentary bout between weekdays and weekends (Table 2). The participants stood for an additional 31 min per day on weekdays and took significantly more steps in

total during weekdays ($p = 0.003$). A significant difference also existed in the number of sedentary bouts accumulated, with participants accumulating more sedentary bouts on weekdays compared with weekends (D11 bouts; $p < 0.001$ with shorter duration ($p = 0.007$). A similar trend was seen when the results were compared within gender except for stepping and mean length of sedentary bouts (Table 2). While significant difference was found in time spent stepping between weekdays and weekends, no significant differences were observed within gender. Furthermore, boys had a shorter mean length of sedentary bouts during weekdays compared with weekends ($p = 0.038$) but not for the girls.

Discussion

This study provides the first descriptive data on the level of objectively measured sitting/lying, standing and stepping in obese children in Malaysia. The findings of the study show that this sample of Malaysian obese children spent a large proportion of their time sedentary (69.6% of their waking hours sitting/lying; approximately 12 h) and spent more time in sedentary activities on weekends. The result was consistent with the result from previous study that examined sedentary behaviours in European children [13]. The difference may exist because the children have more opportunity to engage in physical activities at school or during weekdays. At school, they have more chances to involve in physical activity during physical education lessons and during break or recess, which decreased the time for sedentary behaviours [13]. Meanwhile, during weekends, the children have more opportunity to be sedentary with activities such as TV viewing, playing electronic games and playing computer.

The present study suggests that neither, boys nor girls, meet the average daily steps count recommendations for elementary school children (13 000 steps for boys; 11 000 steps for girls) [14]. Furthermore, using a sex-specific step counts cut-off points for children aged 6–12 years old, boys in the present study were categorized as sedentary (<10 000 step counts) while girls were categorized as low active (7 000–9 499 step counts) [14]. Our results indicate that Malaysian obese children are less active than obese children in the UK [15, 16], European countries [17, 18], USA [19] and Australia [19].

The novelty of this study is that we also highlight the number of sedentary bouts of obese children with a little research in the previous studies [4, 5]. The greatest number of sedentary bouts was accrued during a weekday, which is logical because this is when the greatest amount of transition from standing to sitting occurred especially at schools. However, in this study, the average length of an uninterrupted period of sedentary behaviour (primarily sitting) was higher during weekends with a mean length of 11 min. The results indicate that while children participated in significantly more sedentary bouts during weekdays, these obese children were sedentary in longer continuous bouts during weekends. As home environment plays an important role on physical activity level and sedentary behaviour in children, identifying the long continuous bouts of sedentary behaviour is important. It is a huge responsibility for the family members to create a healthy and active environment for the children to help and motivate them to be active.

The main strength of this study is that this is the first study conducted in Malaysia using activPAL™ monitor that measured sitting/lying, standing and stepping among a sample of Malaysian obese children. This activity monitor has a unique positioning on the thigh that allows the device to distinguish between postures. However, one of the weaknesses of the activPAL™ monitor is that it cannot differentiate between sitting and lying posture. Therefore, we cannot determine whether the children were lying or sitting during sedentary time.

Conclusion

Obese Malaysian school children demonstrate high levels of sitting/lying during both the weekdays and weekends. The results from this study create a greater understanding of obese children's sedentary behaviour patterns and can be used to inform future interventions aiming to decrease sedentary behaviour in children.

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Table 1. Characteristics of respondents (n = 65)

Characteristic	Full sample (n = 65)		Boys (n = 39)		Girls (n = 26)	
Age (years)	10.1	(0.8)	10.2	(0.7)	10.0	(0.9)
Anthropometric measurements						
Height (cm)	140.8	(7.3)	140.8	(7.5)	140.9	(7.0)
Weight (kg)	53.7	(10.2)	52.4	(10.5)	55.5	(9.7)
BMI (kg/m ²)	26.8	(3.2)	26.2	(3.3)	27.7	(2.7)
BMI z-score	2.9	(0.6)	3.0	(0.7)	2.9	(0.4)
ActivPAL data output (per day)						
Sitting/lying (h)	11.8	(1.5)	11.8	(1.6)	11.8	(1.4)
Standing (h)	3.3	(1.0)	3.1	(1.1)	3.4	(1.1)
Stepping (h)	1.9	(0.7)	2.0	(0.7)	1.7	(0.6)
						(2695)
Number of steps	8782	(3141)	9420	(3285)	7826)
Number of sedentary bouts (per day)	89	(22)	87	(23)	91	(20)
Mean length of sedentary bouts(min)	9.0	(5.7)	9.4	(6.1)	8.3	(5.3)

Table 2. Daily activities compared between weekdays and weekends stratified by gender

Characteristics	Weekday mean (SD)			Weekend mean (SD)			
	Boys (n =		Girls (n =	All	Boys (n =		Girls (n =
	All (n = 65)	41)	24)		41)	24)	
Total sitting/lying (h)	11.6(1.8)	11.5 (2.0)	11.8 (1.6)	12.4(1.8)**	12.8 (1.9)††	12.5 (1.7)†	
Standing (h)	3.4 (1.1)	3.3 (1.1)	3.6 (1.2)	2.9 (1.4)**	2.8 (1.6)†	3.0 (1.2)†	
Stepping (h)	2.0 (0.7)	2.1 (0.7)	1.8 (0.6)	1.8 (0.9)*	1.9 (1.0)	1.6 (0.7)	
Number of steps	9189(3289)	9864(3446)	8178(2804)	7797(4116)**	8337(4630)†	6988(3107)†	
Number of sedentary bouts (per day)	92 (24)	91 (26)	94 (20)	81 (25)***	77 (25)††	85 (25)†	
Mean length of sedentary bouts (min)	8.1 (6.7)	8.7 (7.9)	7.4 (4.4)	10.7(6.6)**	11.3 (5.8)†	9.7 (7.7)	

Mean values were significantly different between weekend and weekdays at *p < 0.05; **p < 0.01; ***p < 0.001; mean values were significantly different between weekday and weekend within gender at †p < 0.05; ††p < 0.01.

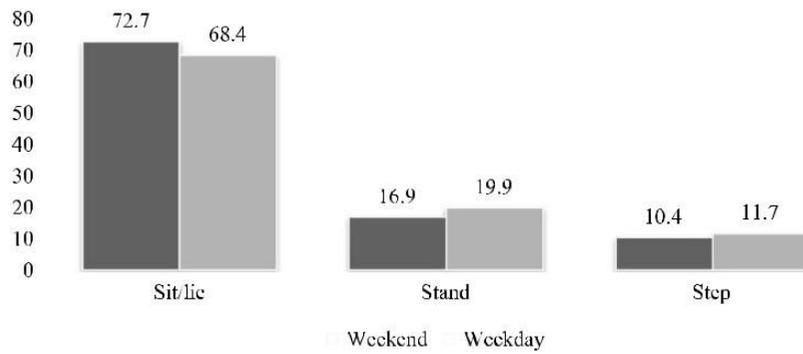


Fig. 1. Comparison of percentage sitting/lying, standing and stepping over 17 h during weekend and weekdays.