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original article

Influence of number of days and valid hours using accelerometry on the estimates of physical activity level in preschool children from Recife, Pernambuco, Brazil

Influência do número de dias e de horas válidas de uso do acelerômetro na estimativa do nível de atividade física em pré-escolares de Recife, Pernambuco, Brasil

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Abstract – A few studies have proposed the number of hours/day and the number of days of monitoring that should be completed to obtain good quality accelerometry data for preschool children. The aim of this study was to analyze how the estimates of physical activity levels and sample profiles (demographic and anthropometric data) vary according the use of different criteria to define valid monitoring periods. Children (n=180) aged three to five years were randomly selected among participants from a longitudinal study performed in Recife, Brazil. Children wore a GT1M Actigraph accelerometer on the right waist during a period of seven days, including the weekend days, using 15 s epochs. A total of 176 children were included in the study (52.8% boys; mean age of 4.3 years [s=0.8]). Using the criterion of 10+ hours/day of wearing time to define a valid monitoring day, 67.0% (n=118) and 36.9% (n=65) of the children showed 3+ and 5+ valid days, respectively. When the criterion of 5+ hours/day was used, the time spent in moderate activity was approximately 10 minutes shorter than when the criterion of 10+ hours/day was used. The criterion of 10+ hours/day for defining a valid monitoring day leads to a sample size reduction and the criterion of 5+ hours/day underestimates the moderate activity level.

Key words: Accelerometry; Exercise; Health behavior; Physical activity; Preschool.

Resumo – *Poucos estudos têm pesquisado acerca do número de horas/dia e o número de dias de monitoramento que devem ser completados para se obter boa qualidade de dados por meio do uso de acelerômetros para crianças pré-escolares. O objetivo deste estudo foi analisar a influencia em se usar diferentes critérios para definir períodos de monitoramento válido na estimativa nos níveis de atividade física e no perfil da amostra. Crianças (n=180) com idade de três a cinco anos foram randomicamente selecionadas entre as participantes de um estudo longitudinal realizado em Recife, Brasil. As crianças usaram um acelerômetro GT1M (Actigraph) à direita da cintura por um período de sete dias consecutivos, incluindo o final de semana, empregando-se epochs de 15 segundos. Um total de 176 crianças foram incluídas no estudo (52,8% meninos; idade média de 4,3 anos [s=0,8]). Usando o critério de 10+ horas/dia de tempo de uso para definir um dia de monitoramento válido, 67,0% (n=118) e 36,9% (n=65) das crianças apresentaram 3+ e 5+ dias válidos, respectivamente. Quando o critério de 5+ horas/dia foi empregado o tempo despendido em atividades moderadas foi aproximadamente 10 minutos menor quando comparado ao critério de 10+ horas/dia. O critério de 10+ horas/dia para definir um dia de monitoramento válido induz uma redução no tamanho da amostra e o critério de 5+ horas/dia subestima o nível de atividade física moderada.*

Palavras-chave: *Acelerometria; Atividade física; Comportamento de saúde; Crianças pré-escolares; Exercício.*

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INTRODUCCION

The number of studies investigating the use of accelerometry to assess physical activity in different populations, including children, has increased in the last years[1]. Particularly in preschoolers (three to five years of age), accelerometry has been the most widely used method for assessing physical activity levels and instrument validation[2,3]. In addition, this method has been more commonly recommended for this age group than instruments such as direct observation or questionnaires for parents or caregivers[2,3].

The preferred use of accelerometry in preschool children over direct observation might be due to the reported unreliability of the latter, which is subjective and might cause reactivity in children[3]. When information is collected based on parental or caregivers reports, the intensity, frequency and duration of activities might not be precisely recalled because the parents/caregivers are not in constant contact with the child[3]. It is also noted that the use of accelerometry in this age group is favorable due to the intermittent character of the performed physical activities, as well as the assessment of physical activity levels in different settings with increased reliability[2,3].

However, it should be noted that the use of accelerometry has some limitations, including the participants' lack of adherence to data collection protocols[4] and the underestimation of non-ambulatory activities that do not involve vertical movement of the trunk[5]. There are also some methodological issues involving the use of accelerometers, especially when assessing young children. Two of these issues include the minimum number of wearing hours per day and the number of days for defining valid monitoring[6].

The appropriate use of accelerometry requires careful decision-making when data are reduced and analyzed because the protocols to be employed in studies involving preschoolers are rare. According to Cliff et al.[6], the existing protocol for the use of accelerometry in preschool children is based on limited evidence and needs to evolve as studies on this method are developed. This is particularly important because few studies have explored the issue of time monitoring when using accelerometers in preschool children and the effects it can have on the quality of the assessment[7,8]. Therefore, the main objective of this study was to analyze how the estimates of physical activity levels and sample profiles (demographic and anthropometric data) vary according the use of different criteria to define valid monitoring periods.

METHODOLOGICAL PROCEDURES

A cross-sectional study in preschool children aged three to five years was utilized as the baseline of a larger project named ELOS-Pre (Longitudinal Study of Health and Well-being in Preschool Children). The ELOS-Pre project was designed to assess longitudinal changes in health conditions, physical activity practices, anthropometric variables, motor skills performance and other lifestyle factors among children of preschool and school age. Data

were collected between September and November 2010 in preschools in Recife, Brazil. The protocol was approved by the Human Research Ethics Committee of the University of Pernambuco (protocol no. 0096.0.097.000-10) and informed written consent was obtained from the children's parents or guardians and the respective school principals. The participants did not receive financial or material compensation for participating in the study.

The target population of the study was three to five-year-old preschool children who were enrolled in both public and private preschools in the six political administrative regions (PAR) of Recife, state of Pernambuco. In the first stage of the sampling process, schools proportionally distributed in the PAR were selected, and in each selected school, all regularly enrolled children were invited to participate in the study (subjects' inclusion criteria). Among those who agreed to participate (n=1,155), 180 children were randomly selected to undertake accelerometry. The number of children to be included in the second stage was chosen based on the number of available accelerometers (25 devices), the time available to perform the study (approximately three months) and the interval period that was needed to download the data files and to set-up the device for the next child to be monitored. None of the selected participants had any physical limitations that restricted their participation in physical activity.

A standardized face-to-face interview was conducted with parents to obtain socio-demographic and behavioral data about the children and their parents. Along with the measures reported by the parents, the children's body weight and height were assessed according to a standardized protocol[9]. Three measurements were performed and the mean value was recorded. Body mass index was determined on the basis of these measurements.

For measuring physical activity, GT1M biaxial accelerometers [ActiGraph, Pensacola, United States] were used. Parents were given instructions on the use of the accelerometers and were trained by the researchers to fit the device to their children every morning and to remove it at night before going to bed. All parents were given a leaflet with illustrated instructions regarding the use of the accelerometers. The device was fixed on an elastic belt and was placed at the waist on the child's right hip. Parents were asked to record in a standard diary the time at which the child donned the device each morning, when it was removed at the end of the day, and also any time that the device was removed and reattached during the day: for example, when the children swam or showered. The wearing time for all children was seven consecutive days, including the weekend days. During the period that the children were monitored, in all school days the parents were contacted in-person by the researchers to ensure that they were following the instructions for the use of the accelerometers.

Accelerometer monitoring was accomplished using 15 s epochs. Data reduction was processed on the Actilife 5 software (Actigraph, Pensacola, United States), using different criteria for the definition of a valid monitoring day (5 to 10 hours/day)[10,11]. To define the intensity of activities performed, cut-off points were adopted as suggested by Pate et al.[12] (moderate:

≥420 counts/15 seconds; vigorous: ≥842 counts/15 seconds). Periods of non-monitoring time were considered when 30 consecutive minutes elapsed without any count record being observed. These periods of typical non-wearing time were excluded from the analysis, as suggested by Bradley et al.[13] and Heitzler et al.[14]. The results were presented as the mean daily time spent in moderate and vigorous physical activities adjusted for the wearing time. On the basis of the current international guidelines children were classified as either having a low physical activity level (cut-off of 60+ minutes per day of moderate to vigorous physical activity [MVPA]) or as active[15].

Data analysis was performed using Stata (version 10). The means, standard deviations (s), and 95% confidence intervals (95% CI) were calculated for continuous variables, and 95% CI were calculated for proportions. Differences between continuous variables were assessed using t- tests and analyses of variance (ANOVA), and differences between categorical variables were assessed using chi-squared tests.

RESULTS

A total of 180 children were selected to participate in the study and no refusals of enrollment were registered. Technical problems with one device resulted in unusable data for three children and another accelerometer was lost. Thus, only 176 children were included in the analysis (52.8% boys) because they had accelerometer data for all 7 days. The subjects' mean age was 4.3 years (s=0.8), and 78.3% of them were from low-income families (income up to two minimum wages). The mean height and body mass were 108.3 centimeters (s=7.2) and 18.8 kilograms (s=4.1), respectively. The highest BMI registered was 39.0 kg/m^2, with a mean of 18.8 kg/m^2 (s=4.2) (Table 1).

By defining a valid day with the criterion of 5+ hours/day of monitoring only 157 out of the 176 children who had data for reduction showed 3+ valid days, resulting in a 10.8% reduction in the sample. When 10+ hours/day of monitoring was used as the criterion, 118 children had 3+ valid days, reducing the sample size by 33.0%. The use of the most rigorous criterion (e.g., 5+ days of valid monitoring, with at least 10 hours/day of wearing time) resulted in a 63.1% reduction in the sample. Only 22 children (12.5%) had seven valid days with at least 10 hours/day of monitoring. The results displayed in Figure 1 show the number of children who remained in the sample when different criteria were used for defining a valid period of monitoring.

It was observed that when two intermediate criteria were used to define a valid monitoring period ('5+ days with 5+ h/day of monitoring' and '3+ days with 10+ h/day of monitoring'), the participants who remained in the sample had a significantly lower weight and BMI, meaning that these criteria might have led to an exclusion of children with higher weight. However, in terms of demographic and socio-economic characteristics, the losses imposed by the different criteria that were used for data reduction did not introduce any differences between the original and the remaining samples after exclusions were taken into consideration (Table 1).

Table 1. Descriptive statistics for socio-demographic and anthropometric variables of the selected sample and the participants that remained in the sample, using four different criteria for defining a valid monitoring day.

Variable	Sample (n=176)		3+ day and 5 h/d of monitoring (n=157)		5+ days and 5 h/d of monitoring (n=122)		3+ days and 10 h/d of monitoring (n=118)		5+ days and 10 h/d of monitoring (n=65)		P value* Chi-square			
	n	%	n	%	n	%	N	%	n	%	1	2	3	4
Gender														
Male	93	52.8	86	54.8	63	51.6	64	54.2	30	46.2	0.15	0.74	0.63	0.21
Female	83	47.2	71	45.2	59	48.4	54	45.8	35	53.8				
Age (years)														
3	35	19.9	29	18.5	22	18.0	20	16.9	9	13.8	0.12	0.92	0.31	0.20
4	48	27.3	42	26.8	37	30.3	34	28.8	19	29.2				
5	93	52.8	86	54.8	63	51.6	64	54.2	37	56.9				
Type of school														
Public	67	38.1	58	36.9	43	35.2	42	35.6	23	35.4	0.45	0.31	0.41	0.63
Private	109	61.9	99	63.1	79	64.8	76	64.4	42	64.6				
Period														
Morning	94	53.4	84	53.5	64	52.5	68	57.6	38	58.5	1.00	0.75	0.15	0.35
Afternoon	82	46.6	73	46.5	58	47.5	50	42.4	27	41.5				
Family income#														
≤2	137	77.8	122	77.7	93	76.2	92	78.0	53	81.5	1.00	0.56	1.00	0.45
>2	39	22.2	35	22.3	29	23.8	26	22.0	12	18.5				
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		P value* (T-test)			
Height (cm)	108.4 (7.3)		108.5 (7.3)		107.9 (7.2)		107.9 (7.2)		108.0 (7.1)		0.64	0.20	0.24	0.59
Weight (kg)	18.9 (4.2)		18.8 (4.2)		18.3 (3.5)		18.2 (3.4)		18.4 (3.6)		0.63	<0.01	<0.01	0.23
BMI (kg/m^2)	18.9 (4.2)		18.8 (4.3)		18.3 (3.5)		18.2 (3.4)		18.4 (3.6)		0.63	<0.01	<0.01	0.23

* p values 1, 2, 3, and 4 were calculated using the chi-squared test (1: Sample X participants with 3+ days and 5+ hours/day of monitoring; 2: Sample X participants with 5+ days and 5+ hours/day of monitoring; 3: Sample X participants with 3+ days and 10+ hours/day of monitoring; 4: Sample X participants with 5+ days and 10+ hours/day of monitoring). # Minimum wages.

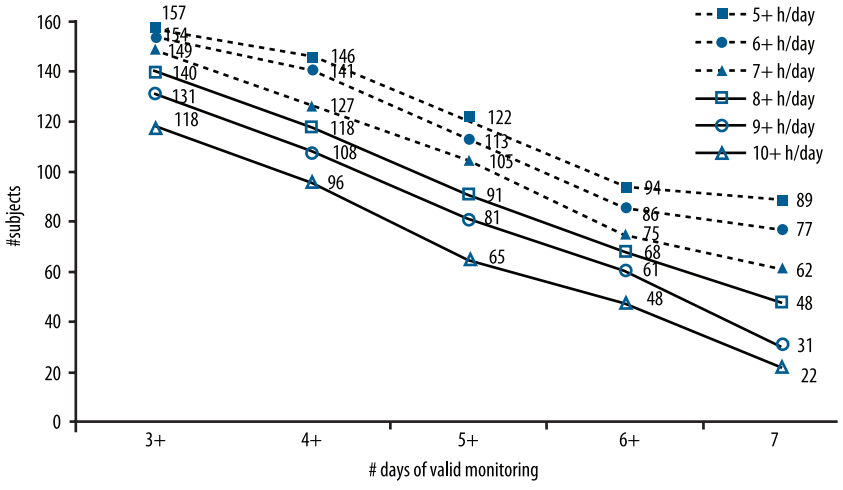

Figure 1. Sample size based on the different criteria for defining valid monitoring, divided by hours/day of accelerometer wearing and number of monitoring days.

It is important to observe how such criteria for defining periods of valid monitoring affect physical activity measurements. In this study, the criterion of 5+ hours/day of monitoring time was found to underestimate the amount of time spent in moderate physical activity by approximately 10 minutes/day compared with the mean values generated when the criterion of 10+ hours/day was used. These findings were independent of the 'number of valid days' (3+ days or 5+ days) criterion. The estimates of vigorous physical activity were not significantly affected neither by the number of valid days and nor by the number of hours/day of wearing time (Figure 2).

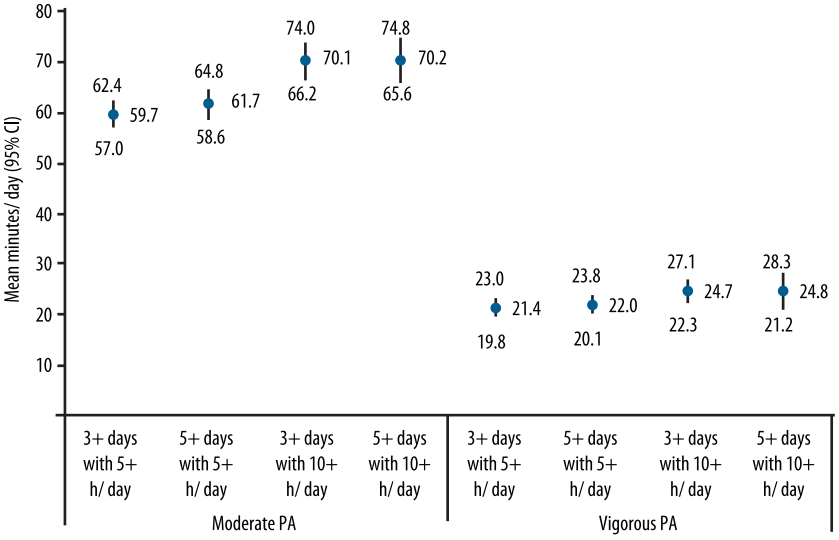

Figure 2. Mean and 95% confidence interval (CI) of time spent daily in moderate and vigorous physical activity based on the different criteria for defining a valid period of monitoring.

It was observed a significant difference (χ^2=7.9; P=0.05) in the prevalence of low physical activity levels (<60 minutes/day of moderate to vigorous physical activity) when different monitoring time criteria were used (Figure 3). The prevalence of low physical activity levels was significantly lower (p≤0.05) when the criterion of 10+ hours/day was used compared with the criterion of 5+ hours/day.

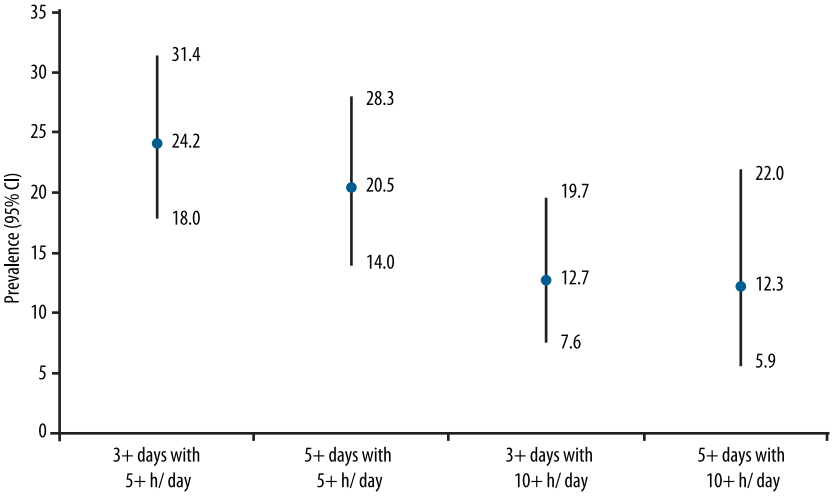

Figure 3. Prevalence of low level of physical activity (<60 minutes/day of MVPA) based on the different criteria for defining a valid period of monitoring.

DISCUSSION

The objective of this study was to analyze how the estimates of physical activity levels and sample profiles (demographic and anthropometric data) vary according the use of different criteria to define valid monitoring periods. The main findings of the present study were as follows: 1) the criterion for a valid monitoring of 5+ days resulted in a large reduction in sample size (greater than 40% in this study); and 2) the criterion of 5+ hours/day of monitoring underestimated the measurement of time spent in moderate physical activity when compared with the use of 10+ hours/day.

The assessment of physical activity levels in children is a great methodological challenge for researchers because reliable measures based on self-reported or parent-reported data, such as questionnaires and diaries, are difficult to obtain[14,16]. Motion sensors have been identified as a potential method to address this difficulty, mainly because they provide information on intensity, duration and total amount of activities performed[2,3]. Although accelerometry was found to be valid when used with small numbers of children in field settings[17], the feasibility of using this device with a large number of preschool children has not been broadly investigated[6].

In the present study, increasing the number of valid days resulted in a greater exclusion of participants than increasing the minimum time of monitoring per day needed for a day to be considered valid. The exclusion of participants that resulted from the establishment of these time monitoring criteria not only can result in the reduction of statistical power but also can lead to a selection bias and compromise the validity of the study. No significant difference was identified in terms of demographic, socioeconomic and anthropometric characteristics between the participants with accelerometer data for reduction (n=176) and those who remained in the sample (n=65) when the most rigorous criteria to define a valid monitoring time was used (5+ days with at least 10 hours/day). These results are in accord with findings that were reported in a validation study of accelerometer measurements to assess physical activity in toddlers[18]. However, these results are in contrast with Mattocks et al.[19], who performed a large field-based study of children and found that the participants who provided valid measures of activity were slightly different from those who did not. This disagreement might be due to the relatively large sample size (>5,000), which maximized power and showed differences that were statistically significant but not clinically relevant.

It was found that the proportion of preschool children who provided valid data was slightly lower compared with results that have been reported in studies of adolescents. In the present study, approximately 67% of the participants had valid data for at least three days for at least 10 hours/day. Using similar procedures to exclude invalid data, the proportions observed by Mattocks et al.[19] and Riddoch et al.[20] were 75% and 78%, respectively.

The proportion of valid data reported by Dolinsky et al.[21] in a study of correlates of physical activity among preschoolers was 86%. However, the criteria used for defining valid data were set as at least three days with at least six hours/day of wearing time.

Ojiambo et al.[7] reported that a minimum of seven to nine days, with at least six hours/day of monitoring were necessary to obtain data with good-quality data. They also reported at least one weekend day must be included. Conversely, Penpraze et al.[8] found that in preschool children, even short monitoring periods (five days of monitoring for three or four hours/day) may provide acceptable measurements (reliability higher than 70%). In addition, the results of the latter demonstrated that the inclusion of a weekend day made relatively little difference, which was contrary to the finding of Ojiambo et al.[7]. The results of the present study tend to disagree with what was reported by Penpraze et al.[8] because it was observed that lower daily time monitoring tends to provide an underestimated measure of moderate physical activity levels and leads to inaccurate estimates in the prevalence of low physical activity levels.

The results showed that data losses due to the malfunction or loss of devices that were observed in the present study (2.2%) are in accord with the findings reported by Toschke et al.[22] in their validation study of physical activity measurements from accelerometry among preschoolers in free-living conditions. However, the proportion of losses was around five times lower than what was found by Van Coevering et al.[23] (~10%). In addition, there were no refusals of enrollment, which suggests a high feasibility of using accelerometers with this age group. Toschke et al.[22] also reported a low percentage of refusals (<5%). The high level of participation of both parents and children in the present study was surprising, considering that a qualitative analysis carried out by Robertson et al.[24] showed that preschool children were unwilling to wear accelerometers at school and during sports because the children felt they put them at risk of stigma and bullying.

As suggested in other studies, some procedures can be employed to avoid data loss and to increase the enrollment of participants[10,25]. These procedures include sending text messages to parents, using the monitor for more than seven days and customizing the devices to the gender of the participant. In the present study, the relatively low proportion of data loss and refusals might be due to the face-to-face approach that was used to teach the parents how to use the devices and the use of printed illustrated instructions (leaflets). Another factor that might have led to the positive compliance was the daily contact between parents and researchers during school days.

The results in figure 2 and figure 3 demonstrate the importance of use the criteria of 10 hours/day to considerate a day valid and show that the number of valid days to considerate a monitoring as valid is irrelevant. Independent the number of valid days (3 or 5) the criteria of 10hours/day increase ~ 10 minutes of moderate physical activity daily. A shorter period of time leads to an underestimation of minutes in moderate physical activity, and this less rigorous criterion also convey an overestimation of

prevalence of low level of physical activity (figure 3). This differences might be consequences of shorter time of monitoring.

On that account the results presented in this investigation indicate the use of the criterion of 3+ days with 10 + hours/day to consider a valid monitoring. As presented before this criterion doesn't lead a severe sample loss or change the sample profile besides a better representation of sample profile and the estimation of physical activity intensity. If more than three days of valid data are needed, researchers must take into account the necessity of implementing additional strategies to improve compliance. These strategies include increasing the number of wearing days or offering incremental incentives based on the number of days of usable data. Alternatively, the sample size may need to be overestimated on the basis of the assumption that for each specific parameter used to define valid monitoring time, a certain proportion of children in this age group will not have complete days of data.

Although the results of the present study might be informative for researchers when deciding about study methodology, this study has some limitations that need to be highlighted. The small number of accelerometers limited the study size. However, because of the relatively small volume of data collected, it was possible to examine each Actigraph file individually to check for errors, thus avoiding spurious patterns of data being accepted as valid. In addition, other important methodological issues were not addressed, including the differences in physical activity outputs that can be generated by the software used to analyze the Actigraph files or the length of consecutive zeros (e.g., 10 or 30 minutes) to detect non wearing time.

CONCLUSIONS

The results of the present study show that the criterion of '5+ hours/day of monitoring' leads to an underestimation of the amount of moderate physical activity performed, whereas 5+ days of monitoring leads to a considerable sample loss. Thus, the use of the criterion of '3+ days of 10+ h/day of monitoring' is more appropriate for preschool children.

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REFERENCES

1. Rowlands AV. Accelerometer assessment of physical activity in children: an update. Pediatr Exerc Sci 2007;19(3):252-66.
2. Oliver M, Schofield GM, Kolt GS. Physical activity in preschoolers: understanding prevalence and measurement issues. Sports Med 2007;37(12):1045-70.

3. Pate RR, O'Neill JR, Mitchell J. Measurement of physical activity in preschool children. Med Sci Sports Exerc 2010;42(3):508-12.
4. Perry MA, Hendrick PA, Hale L, Baxter GD, Milosavljevic S, Dean SG, et al. Utility of the RT3 triaxial accelerometer in free living: an investigation of adherence and data loss. Appl Ergon 2010;4(3):469-76.
5. Corder K, Brage S, Ekelund U. Accelerometers and pedometers: methodology and clinical application. Curr Opin Clin Nutr Metab Care 2007;10(5):597-603.
6. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0-5 years. J Sci Med Sport 2009;12(5):557-67.
7. Ojiambo R, Cuthill R, Budd H, Konstabel K, Casajus JA, Gonzalez-Aguero, et al. Impact of methodological decisions on accelerometer outcome variables in young children. Int J Obes (Lond) 2011;35(Suppl 1):98-103.
8. Penpraze V, Reilly J, MacLean C, Montgomery C, Kelly L, Paton J, et al. Monitoring of physical activity in young children: how much is enough? Pediatr Exerc Sci 2006;18(4):483-91.
9. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Champaign: Human Kinetics; 1988.
10. William HG, Pfeiffer KA, O'Neil JR, Dowda M, McIver KL, Brown WH, et al. Motor Skill Performance and Physical Activity in Preschool Children. Obesity (Silver Spring) 2008;16(6):1421-6.
11. Pfeiffer KA, Dowda M, McIver KL, Pate RR. Factors Related to Objectively Measured Physical Activity in Preschool Children. Pediatr Exerc Sci 2009;21(2):196-208.
12. Pate RR, Almeida MJ, McIver KL, Pfeiffer KA, Dowda M. Validation and calibration of an accelerometer in preschool children. Obesity (Silver Spring) 2006;14(11):2000-6.
13. Bradley RH, McRitchie S, Houts RM, Nader P, O'Brien M. Parenting and the decline of physical activity from age 9 to 15. Inter J Behav Nutr Phys Act 2011;8:33.
14. Heitzler C, Lytle L, Erickson D, Sirard J, Barr-Anderson D, Story M. Physical activity and sedentary activity patterns among children and adolescents: a latent class analysis approach. J Phys Act Health 2011;8(4):457-67.
15. National Association for Sport and Physical Education. Active Start: A Statement of Physical Activity Guidelines for Children from Birth to Age 5, 2nd Edition. USA; 2009.
16. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. Sports Med 2001;31(6):439-54.
17. Kohl HW, Fulton JE, Caspersen CJ. Assessment of physical activity among children and adolescents: a review and synthesis. Prev Med 2000;31(Suppl 2):54-76.
18. Van Cauwenberghe E, Gubbels J, De Bourdeaudhuij I, Cardon G. Feasibility and validity of accelerometer measurements to assess physical activity in toddlers. Inter J Behavl Nutr Phys Act 2011;26:67.
19. Mattocks C, Ness A, Leary S, Tilling K, Blair SN, Shield J, et al. Use of accelerometers in a large field-based study of children: protocols, design issues, and effects on precision. J Phys Act Health 2008;5(Suppl 1):98-111.
20. Riddoch CJ, Andersen LB, Wedderkopp N, Harro M, Klasson-Heggebø L, Sardinha LB, et al. Physical activity levels and patterns of 9 and 15 yr-old European children. Med Sci Sports Exerc 2004;36(1):86-92.
21. Dolinsky DH, Brouwer RJ, Evenson KR, Siega-Riz AM, Østbye T. Correlates of sedentary time and physical activity among preschool-aged children. Prev Chronic Dis 2011;8(6):131.
22. Toschke JA, von Kries R, Rosenfeld E, Toschke AM. Reliability of physical activity measures from accelerometry among preschoolers in free-living conditions. Clin Nutr 2007;26(4):416-20.
23. Van Coevering P, Harnack L, Schmitz K, Fulton JE, Galuska DA, Gao S. Feasibility

of using accelerometers to measure physical activity in young adolescents. Med Sci Sports Exerc 2005;37(5):867-71.
24. Robertson W, Stewart-Brown S, Wilcock E, Oldfield M, Thorogood M. Utility of accelerometers to measure physical activity in children attending an obesity treatment intervention. J Obesity 2011;2011.
25. Purslow LR, Hill C, Saxton J, Corder K, Wardle J: Differences in physical activity and sedentary time in relation to weight in 8-9 year old children. Int J Behav Nutr Phys Act 2008;5:67.

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