Rev Bras Cineantropom Hum

original article

DOI: dx.doi.org/10.5007/1980-0037.2019v21e55973

Effect of number of hours and days of accelerometer use on physical activity estimates in adolescents

Efeito da quantidade de horas e dia de uso do acelerômetro sobre as estimativas de atividade física em adolescentes

Arthur Oliveira Barbosa [1,2]
https://orcid.org/0000-0002-5976-7287
Alcides Prazeres Filho [1,2]
https://orcid.org/0000-0003-2661-090X
José Cazuza de Farias Júnior [1,2,3]
https://orcid.org/0000-0002-1082-6098

Abstract – The study analyzed the effect of number of hours and days of accelerometer use on estimates of physical activity (PA) time in adolescents. Cross-sectional study of 784 adolescents from 10 to 14 years old (53.9% girls). Overlapping 95% confidence intervals (95%CI) were used to compare mean light (LPA), moderate (MPA), vigorous (VPA) and moderate to vigorous (MVPA) physical activity times and prevalence of sufficient PA levels between different numbers of hours (≥6, ≥8 and ≥10 hours/day) and days (≥3, ≥4, ≥5 and 7 days of use). The criterions of ≥6 hours/day with ≥3, ≥4, ≥5 e 7 days and ≥8 hour/day with ≥3, ≥4 e ≥5 days of accelerometer use underestimated, in average, the LPA time in 23.1 and 12.6 min/day, respectively, compared ≥10 hours/day. There were no significant differences in mean MPA, VPA and MVPA times and prevalence of sufficient PA levels between the number of hours and days of use analyzed. To produce accurate estimates of PA time in teenagers, ≥3 days of accelerometer use was adopted for ≥10 hours/day of LPA and ≥ 6 hours/day of MPA, VPA and MVPA.

Key words: Actigraphy; Adolescents; Motor Activity.

Resumo – *Objetivou-se analisar o efeito da quantidade de horas e dias de uso do acelerômetro sobre as estimativas de tempo de atividade física (AF) em adolescentes. Estudo transversal com 784 adolescentes de 10 a 14 anos de idade (53,9% do sexo feminino). Os tempos médios de atividade física leve (AFL), moderada (AFM), vigorosa (AFV), moderada a vigorosa (AFMV) e as prevalências de níveis suficientes de AF entre diferentes quantidades de horas (≥6, ≥8 e ≥10 horas/dia) e dias (≥3, ≥4, ≥5 e 7 dias/uso) de uso do acelerômetro foram comparadas pelas interseções dos intervalos de confiança de 95% (IC95%). Os critérios de ≥6 horas/dia com ≥3, ≥4, ≥5 e 7 dias e ≥8 horas/dia com ≥3, ≥4 e ≥5 dias de uso do acelerômetro subestimaram, em média, o tempo de AFL em 23,1 e 12,6 min/dia, respectivamente, comparados a ≥10 horas/dia.Não houve diferenças significativas nos tempos médios de AFM, AFV, AFMV e nas prevalências de níveis suficientes de AF entre as quantidades de horas e dias de uso analisadas. Para produzir estimativas precisas do tempo de AF em adolescentes foi necessário adotar ≥3 dias de uso do acelerômetro durante ≥10 horas/dia para AFL e ≥6 horas/dia para AFM, AFV e AFMV.*

Palavras-chave: *Actigrafia; Adolescente; Atividade Motora.*

1 Study and Research Group in Epidemiology of Physical Activity, João Pessoa, PB. Brazil.

2 University of Pernambuco and Federal University of Paraíba. Associate Post-Graduation Program in Physical Education. João Pessoa, PB. Brazil.

3 Federal University of Paraíba. Department of Physical Education. João Pessoa, PB. Brazil.

Received: 23 March 2018
Accepted: 12 September 2018

How to cite this article
Barbosa AO, Prazeres Filho A, Farias Júnior JC. Effect of number of hours and days of accelerometer use on physical activity estimates in adolescents. Rev Bras Cineantropom Desempenho Hum 2019, 21:e55973. DOI: http://dx.doi.org/10.5007/1980-0037.2019v21e55973

INTRODUCTION

The last 20 years has seen an increase in the use of accelerometers to measure PA in studies with adolescents[1,2]. However, there is no consensus regarding the criteria established for their data, such as thresholds to determine PA intensities,epochs, periods of non-use and the number of hours and days of userequired for data to be considered valid[3].

In a systematic review of studies with children and adolescents,Cain et al[3]found 6 different definitions for epochs and periods of accelerometer use, 14 for a valid day and 8 for number of days of valid use.Between 9.8% and 46% of the studies did not clearly describe these definitions.With respect to PA thresholds,Romanzini et al[4] identified 23 and 20 thresholds that established MPA and VPA intensities, respectively.

The influence of intensities[2], epochs[5]and periods of non-accelerometer use[6]on PA duration has been investigated in teenagers, but few studies analyzed the minimum number of hours and days the accelerometer was used[7,8]. Thus, the minimum number of hours and days of accelerometer use needed to obtain an accurate measure of PA duration at different intensities (light, moderate and vigorous) has yet to be established.

With a view to overcoming this barrier, it has been recommended that adolescents use the accelerometer throughout the day and for≥7 days[6,7,9,10].In practice, most study participants do not follow this recommendation[11],and adopting this criterion results in a significant decline in sample size[10,11],and greater likelihood of selection bias[9].As such, the number of hours and days of accelerometer use was established arbitrarily[3]and how much they underestimate PA time remains unknown.Identifying the minimum number of hours and days of accelerometer use required to produce an accurate measure of PA duration at different intensities is an important gap that needs to be filled.The aim of this study was to analyze the effect of the number of hours and days an accelerometer is used on estimated LPA, MPA, VPA and MVPA time in teenagers.

METHOD

Study design and sample selection

This is a cross-sectional study that used baseline data (2014) from the "Longitudinal Study of Physical Activity, Sedentary Behavior, Eating Habits and Health of Adolescents" (LONCAAFS). The study was approved by the Human Research Ethics Committee of the Federal University of Paraíba (Protocol no.024/13) all the parents and/or legal guardians gave their informed consent.

The target population of LONCAAFS is composed of adolescents aged between 10 and 14 years, enrolled in grade six of public schools in the city of João Pessoa, Paraíba state, Brazil.Sample calculation was based on the following parameters of a prevalence study:estimated target population of 9,520 adolescents in grade six; outcome prevalence of 50%; 95% confidence

interval; acceptable error of four percent; design affect (*deff*) of two; and an increase of 40% to compensate for possible losses and refusals.These parameters resulted in a sample size of 1,582 adolescents. The present study employed data of adolescents that used an accelerometer (70.4% of the sample). The steps of the sampling process are shown in Figure 1.

All of data were collected by a trained team between February to June and August to December of 2014. The following sociodemographic variables were measured using a questionnaire administered in a face-to-face interview: sex; age (years, categorized as 10-11 and 12-14 years); economic class, determined by the Brazilian Association of Research Companies–ABEP[12]and for analysis purposes the following categories were adopted: A/B [upper class] and C/D/E [lower-middle class].

Physical activity was measured by an ActiGraph GT3X+ accelerometer, and the teenagers were instructed to use it on the right side of their waist, attached by an elastic belt, for seven consecutive days, removing it to sleep, bathe, perform activities in contact with water and martial arts involving falls. All the adolescents received three telephone calls to reinforce the use of the accelerometer.

TheActLife 6.12software was used to download and reduce accelerometer data, in line with the following criteria: 15-second epochs, reintegrated at 60 secondsand;the period of non-use was established as ≥60 consecutive minutes of counts equal to zero[10].The number of hours and days the accelerometer was used in the present study are among the most commonly adopted by adolescents[3]:≥6, ≥8 and ≥10hours/dayand;≥3, ≥4, ≥5 and 7 days of accelerometer use. The time of use of accelerometer was define by difference between period of non-use and time use of device.

All the hours and days of accelerometer use analyzed included≥1 weekend day[8,13].Physical activity intensities were determined by the thresholds proposed byEvenson et al[14]: 101 – 2,295 counts/min for LPA; 2,296 – 4011 counts/min forMPA; ≥4,012 counts/min for VPA;and ≥2,296 counts/min for MVPA.Based on MVPA time estimates at each of the number of hours and days analyzed, the adolescents were classifiedas physically active (≥60 min/day of MVPA) and inactive (<60 min/day of MVPA)[15].

The criterions of excludes were: adolescentsyounger than 10 and older than 14 years; those who exhibited any disability that would impede/limit their physical activity and/or ability to fill out the questionnaire, and individuals who did not use the accelerometer for≥6 hours/day for≥3 days (including≥1weekend day).

Statistical data analysis

Descriptive statistics, including the mean, standard deviation and 95% confidence interval (95%CI), were used for the quantitative variables, and frequency distribution and its 95%CI for the qualitative variables. The intraclass correlation coefficient for a single measure (ICC_s) [intersubject variance + intrasubject variance)] and the Spearman Brown Prophecy procedure were adopted to estimate the accuracy of LPA, MPA, VPA

and MVPA time for each number of hours and days of accelerometer use, using the following formula:

$$ICC = \frac{N \times ICC_s}{1 + (N-1)ICC_s}$$

In which ICCrepresents the accuracy level and N the number of days of accelerometer use (≥3, ≥4, ≥5 and 7 days). ICC values of 0.70 or higher were considered acceptable[16,17].This analysiswas performed in adolescents with at least 7 days using of accelerometer. Due to possible differences in time of use of accelerometeramong adolescents, the ICC analyses was made considering the percentage of time in LPA, MPA, VPA and MVPA each day by dividing thetime using of accelerometer and multiplying by 100 (e.g: [LPA on Monday / time using of accelerometer on Monday] x 100). This approach was repeated for each physical activity intensity.

Mean LPA, MPA, VPA and MVPA times and prevalence of sufficient PA levels in the number of hours and days the accelerometer was used were determined by comparing overlapping 95% confidence levels (95%CI).

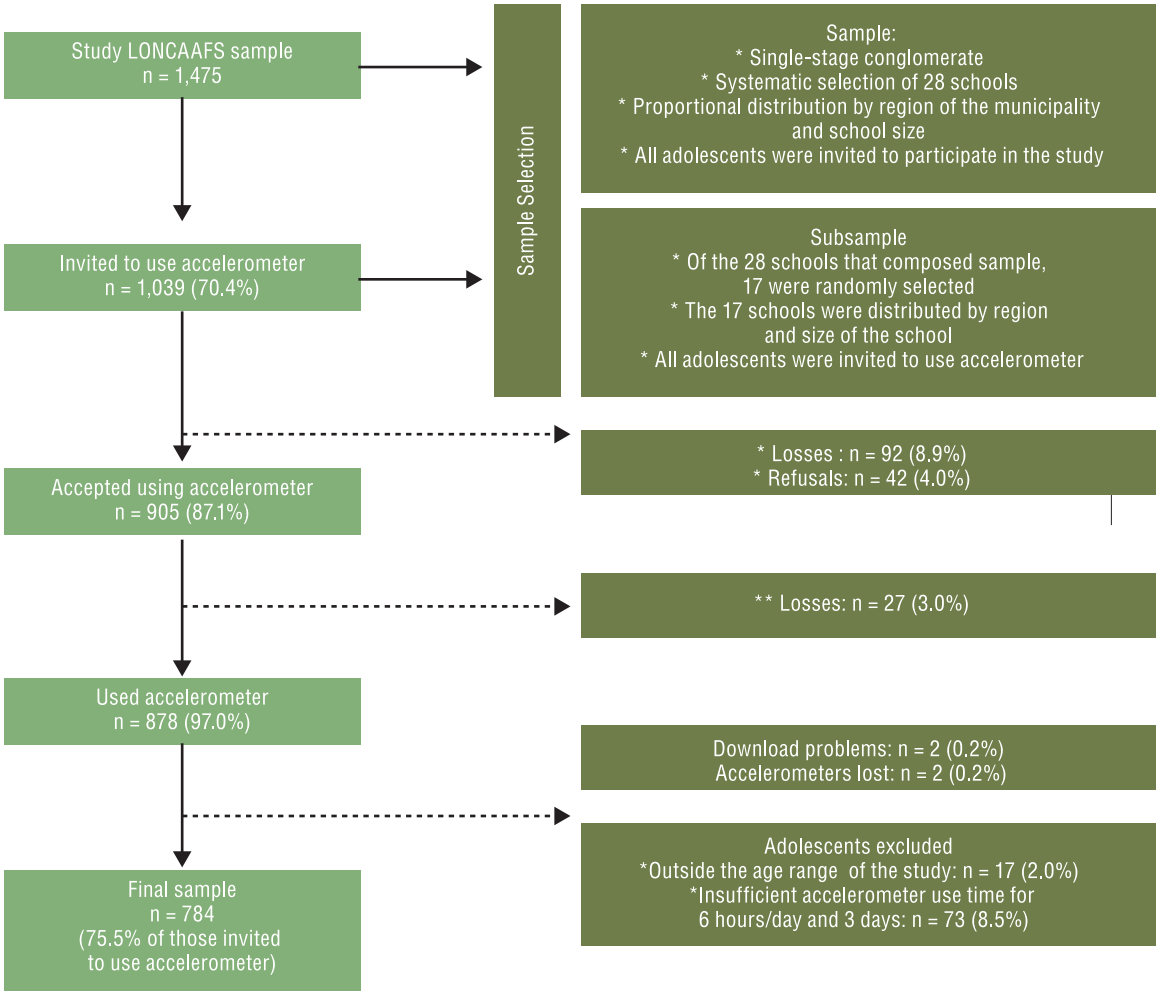

Figure 1. Sample flow chart. Note. *Not returned the Informed Consent signed by the responsible; **Missing adolescent in at least three visits to the school for distribution of the accelerometer.

RESULTS

Of the 1,039 adolescents that used the accelerometer, losses (n = 123), refusals (n = 42) and exclusions (n = 90) accounted for 24.5% of the cases. The final study sample was composed of 784 (75.5%) adolescents aged 10-14 years, who used the accelerometer for≥6 hours/day for ≥3 days (Figure 1). Most of the participants were girls (53.9%), aged 10 – 11 years old (58.6%), belonging to the lower-middle class (61.5%) (data not presented in the tables).

There were no significant differences for the variables sex, age and economic class between those in the sample and subsample ($p<0.05$). A larger percentage of adolescents aged between 12 and 14 years refused to use the accelerometer (26.0% vs. 16.4%; p = 0.005) and did not meet the minimum criteria of≥6 hours/day for≥3 days (9.7% vs. 5.4%; p = 0.019) compared to 10 and 11 years old (data not presented in the tables).

There was an increase in the accuracy of PA measures as more hours and days of accelerometer use were required (Table 1). In general, all the numbers of hours and days of use analyzed exhibited acceptable ICC values, except for ≥6and≥8 hours/day for≥3 days,showing ICC of 0.66for MPA and 0.69 for MVPA.

Table 1. Frequency and intraclass correlation coefficient (ICC) for numbers of hours and days of accelerometer use at different physical activity intensities in adolescents from João Pessoa (PB), Brazil 2014.

Days of accelerometer use	Hours of use per day	n	%	LPA	MPA	VPA	MVPA
				ICC	ICC	ICC	ICC
≥3days	≥6	703	89.7	0.76	0.66	0.68	0.69
≥4days		689	87.9	0.79	0.72	0.74	0.75
≥5days		646	82.0	0.82	0.76	0.78	0.79
7days		431	55.0	0.87	0.82	0.83	0.84
≥3days	≥8	656	83.7	0.76	0.68	0.68	0.69
≥4days		635	81.0	0.81	0.74	0.74	0.75
≥5days		587	75.0	0.84	0.78	0.78	0.79
7days		341	43.5	0.88	0.83	0.84	0.84
≥3days	≥10	584	75.8	0.76	0.71	0.72	0.73
≥4days		562	71.7	0.81	0.77	0.77	0.78
≥5days		504	64.0	0.84	0.80	0.82	0.82
7days		247	31.5	0.88	0.85	0.86	0.86

Note. LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity. ICC: Intraclass correlation coefficient calculated by the Spearman-Brown Formula. ≥1 weekend day was included in the number of hours and days of accelerometer use.

Table 2 shows the mean LPA, MPA, VPA and MVPA times between the different number of hours and days the accelerometer was used.At ≥3, ≥4, ≥5 and 7 days, using the accelerometer for≥6and≥8hours/day underestimated the average LPA time compared to≥10 hours/day. For accelerometer use of≥6 hours/day,the differences varied from18.9(7 days)to 25.2 min/day

(≥4 days)and from 12.8 (7 days) to 14.0 min/day (≥4 days) for ≥8 hours/day.

Maintaining the number of hours per day constant, accelerometer use for≥6 hours/dayfor ≥3and≥4 days underestimated mean LPA time by 14.8 and 13.4 min/day, respectively,compared to 7 days. Using it for≥6 hours/day for ≥3, ≥4, ≥5 or 7 days and for ≥8 hours/day and ≥3, ≥4, ≥5 days underestimated LPA time by 24.8 min/day compared to≥10 hours/day and 7 days(Table 2).

There were no significant differences in mean LPA, MPA, VPA and MVPA times between the number of hours and days the accelerometer was used (Table 2). The prevalence of sufficient PA level varied from7.0% (≥10 hours/day, for≥3 days of use) to 11.7% (≥10 hours/day, for7 days of use), with no significant differences between the number of hours and days of accelerometer use analyzed(data not presented in the tables).

Table 2. Mean times for LPA, MPA, VPA and MVPA (minutes/day), determined from different numbers of hours per day of accelerometer use in adolescents from João Pessoa (PB), Brazil 2014 (n = 703).

Variable	Hours of use	≥3 days			≥4 days			≥5 days			7 days		
		Mean	sd	95%CI	Mean	sd	95%CI	Mean	sd	95%CI	Mean	sd	95%CI
LPA	≥6	334.5*‡	74.8	329.0-340.0	335.9*‡	73.7	330.4-341.4	338.9*	73.1	333.3-344.6	349.3*‡	70.3	342.6-355.9
	≥8	346.9**	71.8	341.4-352.4	348.1**	71.5	342.6-353.7	350.0**	70.9	344.2-355.7	357.5	71.1	349.9-365.1
	≥10	359.7	70.9	354.0-365.4	362.1	69.8	356.3-367.9	363.0	69.0	357.0-369.1	368.2	66.8	359.8-376.5
MPA	≥6	26.8	16.1	25.6-28.0	26.8	16.2	25.6-28.0	27.0	16.2	25.8-28.3	27.0	15.7	25.5-28.5
	≥8	27.7	16.6	26.4-28.9	27.8	16.7	26.5-29.1	27.8	16.8	26.5-29.2	27.1	15.9	25.4-28.8
	≥10	28.5	17.1	27.2-29.9	28.7	17.2	27.3-30.1	28.41	17.3	26.9-29.9	27.8	16.8	25.7-29.9
VPA	≥6	5.1	6.6	4.6-5.6	5.1	6.6	4.6-5.6	5.1	6.8	4.7-5.7	5.2	6.3	4.6-5.8
	≥8	5.2	6.8	4.7-5.8	5.3	6.8	4.7-5.8	5.3	7.0	4.8-5.9	5.2	6.4	4.5-5.9
	≥10	5.5	7.0	4.9-6.0	5.5	7.1	4.9-6.1	5.4	7.1	4.8-6.1	5.3	6.7	4.5-6.2
MVPA	≥6	31.8	21.0	30.3-33.4	31.9	21.1	30.3-33.5	32.23	21.2	30.6-33.9	32.2	20.2	30.3-34.1
	≥8	32.9	21.6	31.3-34.6	33.0	21.7	31.3-34.7	33.2	22.0	31.4-35.0	32.3	20.3	30.1-34.4
	≥10	34.0	22.3	32.2-35.8	34.2	22.5	32.4-36.1	33.9	22.5	31.9-35.8	33.1	21.6	30.4-35.8

Note. sd: standard deviation; 95%CI: 95% confidence interval; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity. *significant differences between ≥6 and ≥10 hours/day; **significant differences between ≥8 and ≥10 hours/day; ‡ significant differences between ≥3 and ≥4 day of use, establishing the number of hours/day criteria.

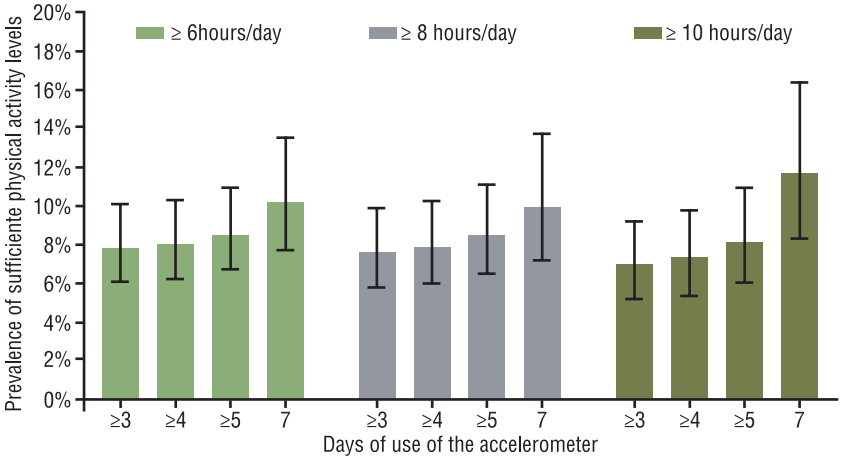

Figure 2. Prevalence (CI95%) of sufficient levels of PA in adolescents determined from different amounts of hours and days of use of the accelerometer, João Pessoa (PB), 2014.

DISCUSSION

To accurately estimate PA time, it was necessary to use an accelerometer for ≥3 days and≥10 hours/day for LPA and ≥6 hours/day for MVPA and should include at least one weekend day for both measures.Furthermore, it is worth noticing that using ≥3 days (included ≥ 1 weekend day) it was possible to maintained the greatest number of participants in analyzes, being 703 and 584 for the rating criterions ≥6 and ≥10 hours/day respectively.

Using the accelerometer for≥6 hours/day and for≥3 days was sufficient to produce acceptably accurate LPA time (ICC≥0.70). In a study with 13 to 18 years old girls,Dowd et al[18]found that using an accelerometer for ≥12 hours/day for ≥5 days resulted in an accurate estimation of LPA time. Sample specificity (girls*vs.*boys/girls) and differences in age ranges (10 to 14 *vs.* 13 to 18 years) in accelerometer use protocols (instruction on use and attachment site)and data reduction procedures may partially explain the divergent study results.In general, using an accelerometer for ≥6 and ≥8 hours/day underestimated mean LPA time by 24.8 min/day compared to ≥10 hours/day, for all the number of days analyzed. This may be due to the fact that, during waking hours, adolescents were involved in LPA around 90% of the time. As such, the less the accelerometer use time, the more the LPA time is underestimated.

In the present study, the results indicate thatthe number of hours per daythe accelerometer is used was more important in estimating LPA time than the number of days. Another important point is that among the hours and days of use analyzed, only≥8 hours/day for 7 days estimates LPA time with no significant differences compared to≥10 hours/day for ≥3, ≥4, ≥5 and 7 days. However, accelerometer use for ≥8 hours/day for 7 days reduced sample size by 56.5%, representing more than twice the decline observed for ≥10 hours/day and≥3 days (24.3%).

Using the accelerometer for ≥6 hours/day for ≥4 days resulted in accurate estimates for MVPA time. These results differ from those found in French[8],American[7]and Irishteenagers[18],who had to use the accelerometer for ≥2, ≥7 and ≥8 days, respectively. Differences in MVPA patterns, age range, sample characteristics and criteria applied to reduce accelerometer data could explain these conflicting results.

In studies conducted with teenagers to determine the number of days of accelerometer use, the authors collected data only in adolescentgirls[18] or obeseteenagers[8] with different age ranges from the present study[7,18]. Moreover, these studies used different data reduction procedures (periods of non-use, hours of use per day), accelerometer brands and/or models and their samples were not representative of their respective target populations[7,8,18].These factors may have influenced the variability of MVPA time data, highlighting the need to include more or fewer days to obtain an accurate measure of MVPA time.

The average MPA, VPA and MVPA times obtained with the different number of hours and days of accelerometer use analyzed were not signifi-

cantly different. However, the ICC values for using the accelerometer for ≥6 hours/day and ≥3 days (≥0.68) were slightly lower than those considered acceptable (≥0.70).

Given that no studies on this issue were found with adolescents, we could not directly compare the results of the present investigation.However, Lima et al[19],in a study with children aged 3 to 5 years, found that using an accelerometer for ≥5 hours/day underestimated MPA time by approximately 10 min/day compared to ≥10 hours/day for ≥3 and ≥5 days of use.Likewise, Masse et al[20] observed that accelerometer use for ≥12 hours/day for ≥3 days underestimated MVPA time by an average of 5 min/day in adults.

The divergent results of these studies can be explained by the different criteria adopted to reduce accelerometer data such as thresholds, epochs and periods of non-use[2,21]. Another possible explanation are the differences in MVPA patterns between the age range of the teenagers[22]or between children, adolescents[7,13]and adults, as well as social, cultural and environmental differences between countries and/or regions of a same country[21,23].

Establishing a minimum number of hours and days of accelerometer use to accurately estimate PA time at different intensities in teenagers is a complex task. This can be observed by the diversity of cutoff points in studies with adolescents in relation to these indicators[2-4,21]; by the involvement of adolescents in physical activities, with marked variations in duration and intensity, on the same day[24,25] and between week days[13].

It is important to highlight that for all the estimates of LPA, MPA, VPA and MVPA times analyzed, at least one weekend day was included, as suggested and adopted in other studies[7,8,13].Complementary analyses indicated significant differences in mean LPA (20.8 min/day), MPA (8.4 min/day), VPA (0.9 min/day)and MVPA times (9.7 min/day) between week and weekend days (data not presented in the tables). In order to produce accurate estimates of PA time, at least one weekend day must be included.

A limitation of this study was the larger percentage of losses, refusals and exclusions in teenagers aged 12 – 14 compared to 10 – 11years old. This may have overestimated LPA time, given that older adolescents spent less time on LPA compared to their younger counterparts (on average 31.5 min/day– data not presented in the tables) and there may not have been any differences in LPA times between the number of hours and days of use analyzed if these individuals had been included in the study.

The strong points include the following:it involved a representative sample of teenagers enrolled in grade six of public schools in João Pessoa,Paraíba(PB) state; it had sufficient power for the analyses proposed (power of 80% [$\beta = 0.8$], ICC of ≥0,30; up to seven applications, $\alpha = 0.05$); and the procedures of turning on, programming, downloading data, distributing and collecting the accelerometers were conducted by a trained team.

It is important to note that caution is needed in applying these results in other contexts or adolescents with different characteristics.Consequently, further studies are needed involving teenagers with different socioeconomic conditions and a broader age range (10 to 18 years old) once that these

variables can influence the physical activity pattern. Besides, it is recommended that researchers could use the procedures applied in this study, once that this strategy can contribute to establish the minimal number of hours and days of accelerometer use, increasing comparability between studies results, minimize sample losses and possible selection bias. Finally, future studies must investigate the impact of accelerometer data reduction in selection bias and in associations between physical activity level and health outcomes.

CONCLUSION

To accurately estimate PA time at all the intensities, we used accelerometer data recorded for ≥3 days, including ≥1weekend day.However, the minimum number of hoursof accelerometer use per day varied according to PA intensity, requiring ≥10 hours/day for LPA and≥6 hours/day for VPA and MVPA.

COMPLIANCE WITH ETHICAL STANDARDS

Funding
The National Council for Scientific and Technological Development (CNPq) and the Research Support Foundation of Paraiba State *(FAPESQ/PB).*

Ethical approval
Ethical approval was obtained from the local Human Research Ethics Committee –Federal University of Paraíba and the protocol (no.024/13) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement
The authors have no conflict of interests to declare.

Author Contributions
Barbosa AO participated in the conception and development of the research problem, writing the manuscript, analysis and data interpretation; Prazeres Filho A carried out a critical revision of the manuscript, analysis and data interpretation and; Farias Júnior JC participated in conceiving the research problem, orientation and all the steps in preparing and revising the manuscript for submission.

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Corresponding Author
Arthur Oliveira Barbosa
Federal University of Paraiba, Department of Physical Education,
Research Study Group in the Epidemiology of Physical Activity –
GEPEAF. Campus I, Cidade Universitaria.
58059-900 - Joao Pessoa, PB
E-mail: b_arthuro@hotmail.com