



Discriminatory capacity of the Brief Physical Activity Assessment Tool

Capacidade discriminatória da Ferramenta Breve de Avaliação da Atividade Física

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ABSTRACT

Introduction: Assessing physical activity (PA) levels in individuals using most subjective questionnaires is difficult, mainly because of their length and complexity. **Objective:** To evaluate the discriminatory capacity of the Brief Physical Activity Assessment Tool (BPAAT) classifications in relation to objectively measured PA parameters. **Methods:** Adult individuals (18-59 years) were included. The discriminatory capacity of the BPAAT was objectively compared using triaxial accelerometers worn for five consecutive days. **Results:** Of the 385 individuals screened for eligibility, 169 individuals were evaluated. The BPAAT was able to categorize participants in the study as sufficiently and insufficiently active for the objective accelerometry variables of counts per minute (cpm), metabolic equivalent of task (MET), and number of steps (Cohen's d values = -0.57 [-0.89; -0.25]; -0.59 [-0.91; -0.27]; -0.52 [-0.84; -0.20], respectively). The same was observed for the times in the different PA classifications. **Conclusion:** The classifications obtained through BPAAT demonstrated the ability to objectively discriminate individuals in accelerometry-derived measures, such as cpm, MET, time at different intensities of PA, and number of steps.

Keywords: Exercise; Fitness trackers; Validation study.

RESUMO

Introdução: A avaliação dos níveis de atividade física (AF) em indivíduos utilizando questionários subjetivos é complexa, principalmente devido à sua extensão e complexidade. **Objetivo:** Avaliar a concordância e a capacidade discriminatória das classificações da Brief Physical Activity Assessment Tool (BPAAT) em relação a parâmetros de AF medidos objetivamente. **Métodos:** Foram incluídos indivíduos adultos (18-59 anos). A concordância e a capacidade discriminatória da BPAAT foram comparadas objetivamente utilizando acelerômetros triaxiais utilizados por cinco dias consecutivos. **Resultados:** Dos 385 indivíduos triados para elegibilidade, 169 foram avaliados. A BPAAT foi capaz de categorizar os participantes do estudo como suficientemente e insuficientemente ativos para as variáveis objetivas de acelerometria de contagem por minuto (cpm), equivalente metabólico da tarefa (MET) e número de passos (valores de Cohen's d = -0,57 [-0,89; -0,25]; -0,59 [-0,91; -0,27]; -0,52 [-0,84; -0,20], respectivamente). O mesmo foi observado para os tempos nas diferentes classificações de AF. **Conclusão:** As classificações obtidas por meio do BPAAT demonstraram a capacidade de discriminar objetivamente indivíduos em medidas derivadas da acelerometria, como cpm, MET, tempo em diferentes intensidades de AF e número de passos.

Palavras-chave: Exercício; Monitores de atividade; Estudo de validação.

Introduction

The global prevalence of physical inactivity exceeded 30% in 2022, increasing by approximately 4 percentage points in 6 years^{1,2}. The Brazilian scenario is worrying, even with possible trends of stabilization in the prevalence of physical inactivity, since this behavior has been associated with the development of chronic non-communicable diseases (type 2 diabetes, cancer, and cardiovascular diseases), increased risk of death from all causes, increased adiposity, and precarious mental health and cognition¹⁻⁴.

Evaluating the practice of physical activity (PA) is essential to understanding its determinants and to developing more precise interventions and public policies, both in research and in clinical practice. Therefore, it is essential to use appropriate instruments that ensure a correct estimation of PA⁵. Currently, there are a variety of instruments available for this measurement, such as doubly labeled water, which is considered the gold standard for assessing PA energy expenditure, self-report questionnaires, and triaxial accelerometers⁶⁻⁸. The latter, in particular, are portable devices attached to the body, known for their accuracy and reliability, capable of measuring the acceleration of PA during the daily routine. However, the high cost makes this equipment inaccessible for widespread use, especially in clinical practice, limiting its use to specific contexts such as scientific research^{9,10}. However, retrospective assessment of PA from self-reported questionnaires represents an attractive, non-invasive, and low-cost means of obtaining information on the type of activity, domain, intensity, duration, context, and social environment¹¹. The International Physical Activity Questionnaire (IPAQ) has been widely used and aims to provide a measure of individuals' habitual PA, having been validated for application in different countries and cultural contexts¹². The IPAQ has two versions: the short version, consisting of eight questions about PA in three specific intensity categories without any separation of specific domains; and the long version, with 27 questions that assess habitual PA in three intensity levels and four specific domains (work, transportation, household activities, and leisure)^{13,14}. Studies have shown that the short version tends to overestimate time spent in moderate-to-vigorous physical activity, and caution is warranted when using it. The long version may not be practical for individual assessments, as it can be tiring and repetitive^{13,15,16}.

An alternative for assessing PA is the Brief Phys-

ical Activity Assessment Tool (BPAAT), a quick-to-use tool containing only two questions that classifies individuals as 'sufficiently active' or 'insufficiently active' based on the frequency and duration of PA over a typical week¹⁷. The BPAAT was originally developed in Australia for use by healthcare professionals (e.g., family physicians) involved in the development of the tool, as well as their patients. In the original study, inter-rater reproducibility (obtained by telephone) and criterion validity (later assessed with Computer Science and Applications accelerometers) demonstrated high test-retest agreement and reasonable intensity-dependent validity¹⁷. In Brazil, the questionnaire went through the stages of translation and semantic equivalence into Portuguese, and may represent a low-cost, fast, and easy-to-apply alternative in the classification of PA, especially in clinical practice, such as in Primary Health Care or in epidemiological studies¹⁸. However, the lack of criterion validation of the instrument for the Brazilian population limits its applicability in research and clinical contexts. Furthermore, the analysis of the agreement between BPAAT and IPAQ may reveal consistency between a short, weekly PA questionnaire and an instrument that has been used in epidemiological studies and has found its way into clinical practice, even though it was developed for epidemiological studies. Thus, the present study aims to evaluate the discriminatory capacity of BPAAT classifications in relation to objectively measured PA parameters.

Methods

Ethical aspects

This research was approved by the Research Ethics Committee of the Federal University of Alagoas, under opinion number 5.391.824. All participants read and signed the informed consent form after being informed of the research objective.

Participants

Adults aged 18 to 59 years were included. Individuals with a body mass index lower than 18.5 kg/m² and higher than 40.0 kg/m², who had any condition that prevented them from performing the anthropometric assessment, answering the questionnaires or using the accelerometer, who had not answered the forms with plausible data or used the triaxial accelerometers as recommended, as well as women who were pregnant

or lactating, were excluded. In addition, individuals who reported having undergone any surgery that could modify their body weight or the assessment of their PA level, and who did not use the accelerometer for at least 10 hours on average per day, were also excluded.

Physical activity assessment tools

• Brief Physical Activity Assessment Tool

The BPAAT is a tool that consists of two short questions, in which each question receives a score and, based on the sum of points, participants are classified as follows: a) sufficiently active (≥ 4 points) and b) insufficiently active (< 4 points). The first question about the frequency of habitual practice of at least 20 minutes of vigorous PA allowed three possible answers: ≥ 3 times/week (4 points), 1-2 times/week (2 points), and none (0 points). The second question was related to the frequency of habitual practice of at least 30 minutes of moderate PA, and had the following options: ≥ 5 times/week (4 points), 3-4 times/week (2 points), 1-2 times/week (1 point), and none (0 points). The BPAAT was administered both in person and via an online form, and compared with accelerometers and the IPAQ, respectively. Using the questionnaire, participants' PA levels were assessed and classified¹⁷. This tool has already been translated into Brazilian Portuguese.¹⁸

• Accelerometry

PA was objectively estimated using triaxial accelerometers (ActiGraph wGT3X-BT, ActiGraph LLC, Pensacola, Florida, United States) to perform criterion validation. The device (4.6 x 3.3 x 1.5 cm and 19 g) was attached to the right hip region immediately after participants completed the questionnaires in person, which were administered at the Nutrition and Metabolism Laboratory of the Federal University of Alagoas, affiliated with the School of Nutrition. Participants used the equipment for at least 5 consecutive days, including weekends, without removing it for any activity other than water activities (bathing, swimming, beach bathing, etc.). In addition, participants were instructed not to change their usual activity routine. To assist in data analysis, participants filled out daily records, handed out at the time the equipment was attached, to collect additional data, such as the time they woke up and went to bed; the start and end times of any activity or physical exercise performed; or the removal of the equipment.

The raw accelerometer data were analyzed using Actilife software version 6.13.4. Discrepant data and

device non-wear time were excluded from the analysis. According to the systematic review by Migueles et al.¹⁹, most studies defined non-wear time as periods of at least 60 minutes, a threshold adopted in the present study. In addition, a minimum bout duration of 10 minutes and an epoch duration of 10 seconds were determined. From this analysis, data on counts per minute (cpm), metabolic equivalent of task (MET), number of steps, time in minutes, and percentage of physical activities (sedentary, light, moderate, vigorous, and very vigorous) and moderate-vigorous PA were provided. The time of use of the accelerometer in minutes for the participants was proportionally adjusted to 14 hours, which was estimated by the time awake and was calculated following the calculation: adjusted minutes = (minutes recorded/time of use (min)) x (14 x 60). The cutoff points used for each of the PA categories were in accordance with Sasaki et al.²⁰.

Complementary variables

Data were collected regarding gender, age, weight, and height, with the latter two variables being used to calculate the body mass index to characterize the sample.

Statistical analysis

Continuous data are presented as mean and standard deviation (SD), while categorical data are presented as frequencies. The analysis of discriminatory agreement was performed by comparing groups (BPAAT classifications) and variables provided by triaxial accelerometry, using the independent samples t-test. Cohen's d was also calculated to verify the effect size. All analyses were conducted using the Jamovi statistical program v. 2.4.14 (The Jamovi Project, Sydney, Australia).

Results

Figure 1 shows the flowchart of participants screened and, subsequently, those included in the analyses of this study. Of the total number of individuals assessed for eligibility, 177 individuals were included; however, 8 of them did not present an average of 10 or more hours of accelerometer use, thus, 169 individuals were included for the criterion validation analyses (Figure 1). Of the total, 127 (75.1%) were female, had a mean age and body mass index of 30.65 (SD = 8.64) years and 29.97 (SD = 4.83) kg/m², respectively. The sample presented an average accelerometer use of 15.94 (SD = 2.78) hours/d, cpm of 489.56 (SD = 149.50), and MET of 1.49 (SD = 0.13), and 109 (64.5%) individuals

were classified as sufficiently active by the BPAAT.

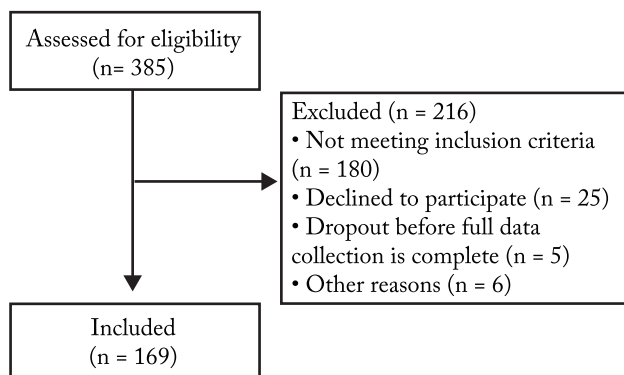


Figure 1 – Flowchart for including participants in the study.

The individuals classified as sufficiently active presented significant differences for all accelerometry parameters evaluated. The comparison between insufficiently and sufficiently active individuals with respect to the accelerometry variables is shown in Table 1. The BPAAT was able to categorize participants in the study as sufficiently and insufficiently active for the objective accelerometry variables of cpm, MET, and number of steps (Cohen's *d* values = 0.57 [-0.89; -0.25]; -0.59 [-0.91; -0.27]; -0.52 [-0.84; -0.20], respectively). The same was observed for the times in the different PA classifications.

Table 1 – Comparison of accelerometer-derived physical activity parameters between BPAAT-defined sufficiently and insufficiently active adults (n = 169).

Accelerometry data	Brief Physical Activity Assessment Tool		p-value*	Cohen's <i>d</i> (Sufficient – Insufficient) [95% CI]**
	Insufficiently active (n = 60)	Sufficiently active (n = 109)		
	Mean (standard deviation)	Mean (standard deviation)		
Time of use (h/d)	16.00 (2.72)	15.90 (2.84)	0.94	0.01 [-0.30; 0.32]
Counts per minute	436.01 (122.73)	519.03 (155.14)	< 0.01	-0.57 [-0.89; -0.25]
Metabolic equivalent of task (3,5 mL O ₂ /kg/min)	1.44 (0.10)	1.52 (0.14)	< 0.01	-0.59 [-0.91; -0.27]
Sedentary time (min/d)	674.04 (38.20)	653.02 (47.24)	< 0.01	0.47 [0.15; 0.79]
% sedentary	80.24 (4.54)	77.74 (5.62)	< 0.01	0.47 [0.15; 0.79]
Light time (min/d)	142.47 (33.97)	154.97 (39.43)	0.04	-0.33 [-0.64; -0.01]
% light	16.96 (4.04)	18.44 (4.69)	< 0.01	-0.50 [-0.82; -0.18]
Moderate time (min/d)	22.81 (11.09)	29.75 (15.09)	< 0.01	-0.50 [-0.82; -0.18]
% moderate	2.71 (1.32)	3.54 (1.79)	< 0.01	-0.50 [-0.82; -0.18]
Vigorous time (min/d)	0.61 (0.86)	1.91 (3.37)	< 0.01	-0.47 [-0.79; -0.15]
% vigorous	0.07 (0.10)	0.22 (0.40)	< 0.01	-0.47 [-0.79; -0.15]
Very vigorous time (min/d)	0.05 (0.16)	0.34 (0.85)	0.01	-0.41 [-0.73; -0.09]
% very vigorous	0.01 (0.01)	0.04 (0.10)	< 0.01	-0.41 [-0.73; -0.09]
Moderate-vigorous physical activity (min/d)	24.06 (12.61)	32.83 (18.26)	< 0.01	-0.53 [-0.85; -0.21]
Number of steps	4624.38 (1634.94)	5698.03 (2259.73)	< 0.01	-0.52 [-0.84; -0.20]

* p-value for the t-test for independent samples;

** Cohen's *d* represents the standardized mean difference between Brief Physical Activity Assessment Tool-defined sufficiently active and insufficiently active groups. Positive values indicate higher values in the sufficiently active group.

Discussion

In the present study, the classifications obtained through BPAAT demonstrated the ability to objectively discriminate individuals in accelerometry-derived measures, such as cpm, MET, time at different intensities of PA, and number of steps. Thus, this tool appears to be interesting for conducting screenings and for application in epidemiological studies, where the time and simplicity of the questions can be determining factors in obtaining information about PA quickly and efficiently from a large number of participants. Tcymbal et al.²¹ identified in a systematic review that the BPAAT presents moderate to good levels of reliability and validity, with a correlation coefficient ranging from 0.45 to 0.64, when compared to other PA questionnaires, such as the 7-day PA Recall, IPAQ, and Active Australia Questionnaire.

Although most of the sample was classified as sufficiently active by the BPAAT, the accelerometry data do not fully corroborate this classification, since the sample's cpm estimates would characterize the average intensity of PA as light, and the MET would represent an expenditure corresponding to sedentary activities^{20,22,23}. However, in the subgroup analysis, individuals who were insufficiently active had cpm means that fall within most of the cutoff points commonly used to

classify PA intensities, corroborating the good agreement between the BPAAT and accelerometers^{20,30-32}. When observing the significant differences between the groups, sufficiently active individuals presented mean cpm values that characterize light PA and borderline MET values for the classification of sedentary PA²⁰. However, it is worth highlighting the wide variation in cutoff points and ways available in the literature to classify PA intensity through accelerometers, which can influence the interpretation of these data^{20,24-26}.

Moreover, for the number of steps, individuals who were sufficiently active according to the BPAAT also had accelerometer-estimated values below the recommended level for active individuals (5698.03; SD = 2259.73 steps/day), commonly assigned to individuals who take ~10000 steps/day²⁷⁻²⁹. Nevertheless, recommendations based on total daily steps do not account for the intensity and cadence of these movements, hindering the interpretation of the activity performed³⁰. When analyzing the variable that best reflects the intensity of PA among sufficiently active individuals, moderate-to-vigorous physical activity, the mean daily time spent in this intensity category (32.83 min/day; SD = 18.26) appears to meet international recommendations (approximately 30–60 minutes on most days of the week). Such levels are considered sufficient to promote health and prevent disease, at least for the majority of the group. In contrast, individuals classified as insufficiently active did not achieve this recommended average (24.06 min/day; SD = 12.61)³¹.

Validation studies of the tool have already observed the agreement of the BPAAT with accelerometers; however, the inability of the BPAAT to adequately identify lower-intensity PA in some cases is also discussed^{17,32-34}. Other short self-report tools have also shown good agreement with accelerometers, but the analysis and choice of method for evaluating accelerometry data appear to play an important role in these tools' ability to identify these types of activities^{35,36}. Furthermore, for moderate and vigorous PA, in the study by Puig-Ribera et al.³², the BPAAT showed moderate validity relative to accelerometry, reinforcing the tool's ability to adequately dichotomize groups. Moreover, it is important to take into account possible factors that may influence the BPAAT's ability to agree with the objective method, such as the overestimation of participants' physical activity level due to the embarrassment of reporting PA patterns considered unhealthy, and the limitation of accelerometers in estimating expenditure

in some types of activity, such as aquatic and some strength exercises.

The present study has some limitations that should be highlighted. The BPAAT, like any self-report instrument, such as the IPAQ-Short, may introduce recall bias by over- or underestimating the frequency, intensity, and duration of PA. In addition, the interpretation of the questions may influence the answers. However, the use of subjective tools to assess PA is essential, as the cost of equipment for objective assessment is considered high and difficult to apply in daily life. Another limitation is the use of triaxial accelerometers, which did not allow the assessment of aquatic activities or activities involving specific movement of the upper and lower limbs with or without load, which may limit the ability to monitor daily activities in some participants. Furthermore, most participants were women (70.9% in the subjective comparison and 75.1% in the criterion validity), which may limit the generalizability of the results to males. Finally, it should be taken into account that the BPAAT is a screening tool, which attempts to provide a global assessment of the PA performed by individuals, and is not able to accurately verify differences in type or volume, context, or specific domains.

Thus, it is possible to conclude that the BPAAT is a practical and quick tool, capable of discriminating objective accelerometer measurements in the categorization of PA in adults. Therefore, in a simple and cost-free manner, the BPAAT allows for a simplified assessment of habitual PA, which can be used in clinical screenings in Primary Health Care or even in epidemiological studies, in contexts where time and costs may prevent the use of more complex and lengthy questionnaires or triaxial accelerometers. It is also suggested that studies be conducted to evaluate the measurement properties of the tool in other population groups, such as adolescents and the elderly.

Conflict of interest

The authors declare no conflict of interest.

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Author's contributions

Macena ML: Conceptualization; Methodology; Validation; Formal analysis; Investigation; Data curation; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Paula DTC: Methodology; Formal analysis; Investigation; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Gama IRS and Soares DB: Formal analysis; Investigation; Writing – original draft; Approval of the final version. Ferro DC, Carnaúba RTL and Silva MECM: Investigation; Writing – original draft; Approval of the final version. Silva Júnior AE: Methodology; Formal analysis; Investigation; Data curation; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Lima LRA: Conceptualization; Formal analysis; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Gonçalves EM: Formal analysis; Writing – original draft; Writing – review & editing; Approval of the final version. Bueno NB: Conceptualization; Formal analysis; Data curation; Supervision; Project administration; Writing – original draft; Writing – review & editing; Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

Availability of research data and other materials

The contents will be available at the time of publication of the article.

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Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Anonymous

Dear editors and authors, I am submitting my suggestions for the manuscript "Criterion validity of the Brief Physical Activity Assessment Tool" in Portuguese, as the authors are Brazilian and the journal is also based in Brazil.

In this regard, I would like to emphasize that the study is important because it provides an additional and feasible alternative for monitoring physical activity practice in epidemiological studies. In this sense, I believe it is important to have different instruments available.

Nevertheless, there are points that could be improved and revised in the study, namely:

- Tables: They are written in both Portuguese and English.
- ROC curve graph: It is illegible and confusing. I suggest revising the method and organizing one ROC curve for each pair of variables that were correlated in the criterion analysis.
- Article content and logic: The study could be simplified. If the idea is to present a criterion for sufficient physical activity, what exactly was the cutoff point identified by the authors?
- After all, how does this new questionnaire establish a physical activity criterion if it is already a nominal variable and not a continuous variable?
- Criterion analysis is established when we have a continuous variable (e.g., body mass) and want to identify which value in this variable is closest to the gold standard criterion using another type of instrument that already has a predefined cutoff.
- Considering this, the present article did not establish a new cutoff point.
- The authors validated the applied questionnaire using accelerometry as the gold standard. However, no criterion was identified for the questionnaire, as it has the characteristics of a nominal variable. Additionally, clusters of sufficiently active and insufficiently active individuals were assessed, and ranges of number of steps (mean + confidence intervals)

and counts per minute were reported for these clusters, which is appropriate for a validation study.

- Another point is that the nature of the evaluated questionnaire does not allow for the establishment of a criterion. It indicates that, in practice, the questionnaire significantly discriminates between more and less active individuals according to accelerometry.
- The main criticism of the study is that the accelerometer itself is also an indirect measure.
- However, it is feasible to establish the validation of the questionnaire through this method for epidemiological studies.
- Finally, I strongly suggest that the authors remove the IPAQ from the study methodology, as there is no reason to cross data from two questionnaires in a study that already includes a more direct standard such as accelerometry. Moreover, the IPAQ has already demonstrated its validity in several other studies.

Final decision (recommendation)

- Major revisions required.

Reviewer B

Anonymous

- Was any indication of plagiarism observed in the manuscript?
No
- Did the authors provide clarification on the ethical procedures adopted for conducting the research?
Yes
- **Comments to the author**
- Some comments to improve the document.

Abstract

- Line 9. The sentence requires improvement to enhance clarity and correctness in English.

Methods / Aim

- Page 4, lines 24–25. The stated aim does not explicitly include the comparison between BPAAT and IPAQ. Please rewrite the objective to clearly reflect

this comparison and improve overall comprehension.

- Methods / Physical Activity Assessment
- Page 6, line 22. Replace “were” with “was”, as physical activity is a singular construct. In addition, please use the abbreviation PA instead of writing physical activity in full. Ensure this correction is applied consistently throughout the entire manuscript.
- Page 7, lines 8–9. Add “the” before time, start, and removal. More generally, the manuscript would benefit from professional technical editing to improve the quality and precision of the English language.
- Page 7, line 12. The statement indicating that data were excluded when participants used the device for less than 60 minutes appears to be incorrect. Based on current methodological standards, this criterion is questionable. Please clarify and justify this decision. You are strongly encouraged to review and align your procedures with the following reference:
- Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Delisle Nyström, C., Mora-Gonzalez, J., Löf, M., Labayen, I., Ruiz, J. R., & Ortega, F. B. (2017). Accelerometer data collection and processing criteria to assess physical activity and other outcomes: A systematic review and practical considerations. *Sports Medicine*, 47(9), 1821–1845. <https://doi.org/10.1007/s40279-017-0716-0>
- Figures and Tables
- Figure 1. The figure needs substantial improvement. It is not sufficiently clear and does not follow the standard structure of a flowchart. Please revise it to improve readability and methodological transparency.
- Page 8, lines 23–24. The values reported in these

lines do not match those presented in Table 1. Please verify and correct these inconsistencies.

- Table 1. Upon reviewing the data, the table is difficult to interpret. It appears that the cross-tabulation may be incorrectly configured. Please revise the table structure to ensure clarity and coherence.

Results

- The narrative description of the results is very limited. The tables are not adequately explained, and the reader is left without a clear interpretation of the findings. A much more detailed and explanatory presentation of the results is required.
- Table 2. The information presented is confusing. It is unclear whether the reported effect size refers to the comparison between sufficient and insufficient PA levels or whether it represents a comparison with accelerometry-based measures. This needs to be explicitly clarified in both the table and the accompanying text.

Discussion

- Although the discussion is generally well written, it does not sufficiently engage with the study’s own results. The findings of the present study are only briefly addressed, while greater emphasis is placed on discussing results from other studies in isolation. The discussion should more clearly interpret and contrast the current findings with existing literature, using the study’s data as the central reference point.

Final decision (recommendation)

- Major revisions required.