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Analyzing the Gender-Specific Criterion Validity of the Physical Activity Questionnaire for Children (PAQ-C) Among Urban Children from Croatia

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Abstract

The aim of this study was to examine the gender-specific criterion validity of the Physical Activity Questionnaire for Children (PAQ-C) in a sample of urban Croatian early school-age children. The participants were 80 children (aged 9-11 years; 36 girls, 44 boys) from southern Croatia. The PAQ-C was used to indirectly measure physical activity (PA), whereas the GENEActiv accelerometers were used to obtain data on PA directly. Spearman's correlations between variables, and forward multiple regressions were calculated separately for boys and girls. The differences in the studied variables between genders were established via a t-test for independent samples. Boys reported higher PAQ-C scores (t test = 3.6, $p < 0.05$), had more vigorous PA (t test = 3.87, $p < 0.05$), and performed more steps than girls did (t test = 3.44, $p < 0.05$). The correlations between the PAQ-C and accelerometer-derived data were similar in magnitude across genders. Vigorous PA was determinant of the PAQ-C in boys (Beta = 0.44, $p < 0.05$), and moderate PA was found to be a determinant of the PAQ-C in girls (Beta = 0.51, $p < 0.05$). While the criterion validity of the PAQ-C is similar for both boys and girls, by acknowledging and addressing potential gender differences in activity patterns associated with questionnaire-based scores, we can develop more effective strategies to encourage PA in children.

Keywords: children, adolescent, survey, accelerometry

Introduction

The lack of physical activity (PA) in children, particularly urban children, is a growing concern with significant implications for their health and well-being (Marinho, Neiva, Marques, Lopes, & Morais, 2022). Indeed, urban environments often present challenges to staying active, such as limited access to safe outdoor spaces, increased screen time, and a reliance on motorized transportation. This sedentary lifestyle contributes to an increase in childhood obesity, cardiovascular problems, and other health issues. Furthermore, a lack of PA can negatively impact children's mental health, leading to increased stress, anxiety, and depression. The decline in PA among urban children is a complex issue influenced by various factors, including parental attitudes, safety concerns, and the availability of engaging recreational opportunities. Addressing this problem requires a multifaceted approach

involving families, schools, and communities. Creating safe and accessible spaces for play, promoting active transportation, and integrating PA into school curricula are crucial steps toward fostering a more active lifestyle for urban children (Marques, Sallis, Martins, Diniz, & Carreiro Da Costa, 2014; Scheller, Sterr, Humpe, Mess, & Bachner, 2024).

The objective evaluation of any attribute, such as PA level, relies heavily on the selection of appropriate measurement tools. These tools should provide reliable, effective, and valid measurements of the specific characteristic or capacity being assessed (Phillips et al., 2021). The tools used to measure PA levels can be broadly categorized into direct and indirect methods. Direct measurement tools offer an objective quantification of movement and energy expenditure, providing precise data on the intensity, duration, and frequency of physical activities. Examples of direct



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measurement tools include accelerometers, pedometers, heart rate monitors, and direct observation by trained professionals. These tools and techniques provide valuable insights into various aspects of PA, enabling researchers and practitioners to assess and monitor PA levels accurately (Phillips et al., 2021).

Questionnaires are a common method for assessing PA in children because of their ease of use and low cost. They offer valuable insights into PA patterns and can be administered to large populations. However, questionnaires rely on self-reports or parental recall, which can be subject to bias and inaccuracies. Children may have difficulty recalling specific activities or estimating their duration, leading to overestimation or underestimation of PA levels. Additionally, questionnaires may not capture the intensity or type of activity accurately. Despite these limitations, questionnaires provide useful tools for understanding PA behaviors in children, especially when combined with other assessment methods for a more comprehensive evaluation (Amor-Barbosa et al., 2021; Mehreen et al., 2020).

Direct measurements of PA, particularly using accelerometers, offer a more objective and accurate assessment than self-reported methods do. Accelerometers provide continuous data on movement intensity and duration, capturing even subtle activities that may be missed by questionnaires. This detailed information allows for a precise evaluation of PA patterns and energy expenditure in children. However, accelerometers can be expensive, require technical expertise for data processing, and may not capture all types of activities, such as swimming or cycling. Additionally, wearing the device can be cumbersome for some children, potentially affecting their natural activity patterns. Despite these limitations, accelerometers provide valuable insights into children's activity levels and are increasingly used in research and clinical settings to promote healthier lifestyles (Eckelt, Hutmacher, Steffgen, & Bund, 2023; Zhang et al., 2024).

Accelerometers provide objective data on PA intensity and duration but can be expensive and may not capture all activity types. Questionnaires are cost-effective and easy to administer but rely on recall and can be subject to bias. Studies evaluating the correlation between these two methods are crucial for understanding the strengths and weaknesses of each approach (Warmath et al., 2021). By comparing accelerometer data with questionnaire responses, researchers can identify discrepancies and potential sources of error. This knowledge helps improve the accuracy of PA assessments in children and informs the development of more effective interventions to promote active lifestyles. Ultimately, combining data from both methods can provide a more comprehensive understanding of children's activity patterns.

Gender can be a significant factor influencing the validity of PA questionnaires in children. Boys and girls may have different perceptions and interpretations of PA, leading to variations in how they respond to questionnaires. For example, boys may be more likely to overreport high-intensity activities, whereas girls may be more likely to underreport them. Additionally, societal expectations and gender stereotypes can influence how children perceive and report their activity levels. Boys may feel pressured to portray themselves as active and athletic, whereas girls may downplay their PA to conform to traditional gender roles (Lago-Ballesteros, García-Pascual, González-Valeiro, & Fernández-Villarino, 2021). These biases can affect the accuracy of self-reported data and lead to discrepancies between perceived and actual PA levels. Furthermore, girls may participate in different types of PA than boys do, which may not be adequately cap-

tured by standardized questionnaires. These questionnaires may not include activities that are more common among girls, such as dance or gymnastics, leading to an underestimation of their actual PA levels. Therefore, it is essential to consider gender-specific factors when designing and interpreting PA questionnaires for children to improve their validity and ensure accurate assessments of PA levels in both boys and girls. Moreover, to the best of our knowledge, no study has examined this problem in southeastern Europe (i.e., the territory of former Yugoslavia).

The aim of this study was to evaluate the gender-specific criterion validity of the Physical Activity Questionnaire for Children (PAQ-C) in measuring PA, specifically among urban children in Croatia. This study evaluated whether the PAQ-C is equally valid for both boys and girls in this population. Authors were of the opinion that it is crucial because, as discussed earlier, gender can influence how children perceive and report their PA, potentially affecting the accuracy of questionnaire-based assessments. To achieve this aim, this study correlated the results obtained from the PAQ-C with objective measures of PA collected via accelerometers. We hypothesized that the PAQ-C would be an equally valid tool for the measurement of PA in both boys and girls.

Materials and methods

Participants

The participants were elementary school children aged 9-11 years in Split, Croatia (n=80, 36 girls). Researchers collaborated with a single school in the city, where all the participating children were enrolled and regularly attended physical education classes. To ensure ethical participation, the researchers first informed school officials about the study's purpose and procedures. School principals then facilitated meetings with parents to discuss the study in detail, including its aims, methods, potential risks, and benefits. Parents were provided with consent forms, and more than 90% of those attending the meetings agreed to allow their children to participate. The study initially included 87 children who met the inclusion criteria: regular attendance in physical education and absence of any illness or injury in the week leading up to the study. Children were excluded if they had motor or functional impairments, health conditions preventing participation in physical education, or experienced illness or injury in the week before or during the study. The initial sample size was reduced because of several factors (i.e., technical issues arose with the accelerometer measurements used to track PA; some children had inconsistent data, and others experienced illness or injury during the study period). Study was approved by Ethical Board of Faculty of Kinesiology, Zagreb, Croatia.

Variables

The variables in this study included participants' gender (male/female; on the basis of school records), age (in years), and PA obtained via direct and indirect measurements.

To measure PA levels indirectly, this study used the PAQ-C, widely used questionnaire for assessing PA in children (Lilic et al., 2024). This questionnaire asks children aged 8 to 16 years to recall their physical activities over the past seven days. It covers various types of activities, including vigorous activities such as running, moderate activities such as swimming, walking, and sedentary activities such as watching TV or doing homework. The children reported how many days and minutes they spent on each activity, and their answers were used to calculate an overall PA score ranging from 1 (low) to 5 (high). The questionnaire also assessed sedentary behavior by asking children

to report their daily time spent on activities such as watching television, playing computer games, using the internet, doing homework, listening to music, and reading. The children completed the questionnaires themselves in small groups to ensure understanding and accurate responses.

To objectively measure PA, the study utilized GENEActiv triaxial accelerometers (Activinsights Ltd., Cambs, UK). The devices were worn by the participants on their wrists for a Thursday and Friday (school days), Saturday and Sunday. Later, we calculated average of school days and multiplied by five, and added results of Saturday and Sunday to define the overall week-activity. The GENEActiv accelerometers are specifically designed to capture detailed movement data, making them suitable for children aged 7-14 years (Price et al., 2018; Ricardo et al., 2020). The devices were programmed to record acceleration data at a high frequency, ensuring accurate capture of even subtle movements. The participants were instructed to wear the accelerometers at all times, even during sleep, swimming, and showering. After the monitoring period, the devices were collected, and the recorded data were downloaded to a computer via specialized software. This software facilitated the cleaning and processing of the raw acceleration data, including the removal of any periods when the device was not worn. Importantly, the study period did not include holidays, ensuring that weekday activity patterns reflected typical school schedules. In this study, we observed the following accelerometer-derived variables: number of performed steps (STEPS), sedentary time (Sedentary), light PA (PA-light), moderate PA (PA-moderate), and vigorous PA (PA-vigorous).

Statistics

The Kolmogorov-Smirnov test was used to verify the normal distribution of the data. Descriptive statistics, including means and standard deviations, were then calculated to sum-

marize the key characteristics of the data.

To investigate potential sex differences in PA levels, an independent samples t-test was conducted. Pearson's correlation coefficients were calculated to examine the associations between variables. These correlations were interpreted on a scale ranging from range of 0.00–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.69 (moderate), 0.70–0.89 (strong), and 0.90–1.00 (very strong), providing a clear indication of the strength of the associations (Akoglu, 2018). Finally, multiple regressions with accelerometer-based data as predictors and PAQ-C as criterion were performed to define the multivariate associations between predictors as criterion. Owing to the possible collinearity of predictors, a forward stepwise model of multiple regression was applied. Correlation analysis and multiple regressions were performed separately for boys and girls, allowing for a detailed examination of potential gender-specific patterns in the relationships between variables. Methodologically speaking, authors are aware that it would be correct to observe accelerometer-based data as criterion, but due to number of variables (e.g. more variables derived throughout direct measurement by accelerometer), and only one derived by PAQ-C this approach was not possible in multiple regression calculation, and therefore specified analyses (with accelerometer data being predictors of PAQ-C) were done.

Statistica ver. 14.5 (Tibco, Inc., Palo Alto, CA, USA) was used for all analyses, and a p-value of 0.05 was applied.

Results

The descriptive statistics and differences in the study variables between boys and girls are presented in Table 1. The boys had higher PAQ-C score (t test =3.6, p<0.001). Additionally, when the accelerometer-obtained data were analyzed, boys performed more steps (t test =3.44, p<0.001) and had more vigorous PA (t test =3.87, p<0.001) than girls did.

Table 1. Descriptive statistics and t-test differences between genders

	Girls		Boys		T-test		
	Mean	Std.Dev.	Mean	Std.Dev.	t-value	df	p
PAQ-C (score)	3.23	0.68	3.75	0.61	-3.61	78	0.001
STEPS (count/day)	11816	3468	14640	3784	-3.45	78	0.001
Sednetary (min/day)	438.63	108.00	438.00	128.61	0.02	78	0.981
PA-light (min/day)	332.23	88.69	335.38	130.78	-0.12	78	0.903
PA-moderate (min/day)	180.23	48.91	185.28	51.22	-0.45	78	0.656
PA-vigorous (min/day)	23.17	14.44	41.03	24.32	-3.88	78	0.001

Legend: PAQ-C – Physical Activity Questionnaire for Children; STEPS - number of performed steps; PA – physical activity

The correlations between the study variables for boys are presented in Table 1. The PAQ-C-derived PA score was significantly correlated with the STEPS score (R=0.31, p<0.05; weak

correlation) and the PA-vigorous score (R=0.39, p<0.05; weak correlation), indicating that the total PA, as evidenced by the PAQ-C, in boys was evidently a result of vigorous PA.

Table 2. Pearson's correlations between study variables in boys (* indicates statistical significance of p<0.05)

Boys	PAQ-C	STEPS	Sedentary	PA-light	PA-moderate
STEPS	0.31*	-			
Sedentary	-0.01	-0.21	-		
PA-light	-0.13	0.00	-0.73*	-	
PA-moderate	0.19	0.68*	-0.07	-0.18	-
PA-vigorous	0.39*	0.68*	-0.35*	0.21	0.29

Legend: PAQ-C – Physical Activity Questionnaire for Children; STEPS - number of performed steps; PA – physical activity

Table 3. Correlations between study variables in girls (* indicates statistical significance of $p < 0.05$)

Girls	PAQ-C	STEPS	Sedentary	PA-light	PA-moderate
STEPS	0.12	-			
Sedentary	-0.30	-0.39*	-		
PA-light	0.09	0.53*	-0.18	-	
PA-moderate	0.39*	0.66*	-0.68*	0.38*	-
PA-vigorous	0.30	0.73*	-0.38*	0.15	0.53*

Legend: PAQ-C – Physical Activity Questionnaire for Children; STEPS - number of performed steps; PA – physical activity

When correlations were calculated specifically for girls, the PAQ-C was significantly correlated solely with the PA-moderate ($R = 0.39, p < 0.01$; weak correlation) (Table 2).

The results of the multiple regression with the PAQ-C score as the criterion and accelerometer-based data as predictors are presented in Table 4. Among boys, multiple regression retained the PAS-vigorous ($Beta = 0.44, p < 0.05$) and PA-moderate ($Beta = -0.22, p > 0.05$) variables in the signifi-

cant regression model ($R^2 = 0.20, p < 0.01$). Among girls, forward stepwise regression consisted of three variables, specifically, STEPS ($Beta = -0.50, p > 0.05$), PA-moderate ($Beta = 0.51, p < 0.05$), and PA-vigorous ($Beta = 0.39, p > 0.05$), and model explained 25% of the criterion variance ($R^2 = 0.20, p < 0.05$). Notably, PA-vigorous in boys, and PA-moderate in girls were significantly partially associated with PAQ-C (criterion).

Table 4. Multiple regression calculation (forward stepwise model) for PAQ-C criterion in boys and girls

	Boys			Girls		
	Beta	B	p	Beta	B	p
STEPS				-0.50	0.01	0.06
Sedentary						
PA-light	-0.22	0.01	0.13			
PA-moderate				0.51	0.01	0.02
PA-vigorous	0.44	0.01	0.001	0.39	0.01	0.09
Multiple R	0.45			0.51		
R ²	0.20			0.25		
p	0.01			0.02		

Legend: PAQ-C – Physical Activity Questionnaire for Children; STEPS - number of performed steps; PA – physical activity; R² – coefficient of determination; Beta – standardized regression coefficient; B – non-standardized regression coefficient

Discussion

This study aimed to evaluate the gender-specific validity of the PAQ-C with respect to its association with direct measurement of PA in urban children from Croatia. The results revealed several important findings. First, the correlations between the PAQ-C and the direct measurement of PA are similar in magnitude across genders. Therefore, our initial study hypothesis should be accepted. However, the gender-specific validity of the PAQ-C is evident on the basis of the differences in accelerometer-based activity patterns correlated with the PAQ-C in boys and girls. Specifically, vigorous PA was a stronger determinant of the questionnaire-based evaluation of PAL in boys. Moreover, moderate PA was found to be a determinant of the PAQ-C score in girls.

Establishing a strong correlation between questionnaire-based and accelerometer-based evaluations of PA in children is of paramount importance for several reasons. First, questionnaires rely on self-reports, which can be subject to recall bias and social desirability bias, particularly in children (Kwon et al., 2020). Children may overestimate or underestimate their PA levels, leading to inaccurate assessments. Accelerometers, on the other hand, provide objective and continuous measurements of movement, offering a more accurate representation of actual PA levels (Ricardo et al., 2020). By comparing these two methods, researchers can gain

a better understanding of the potential biases associated with questionnaires and develop strategies to improve their accuracy. This is crucial for obtaining reliable data on children's PA patterns, which are essential for informing public health interventions and promoting healthy lifestyles.

Furthermore, understanding the relationship between questionnaire-based and accelerometer-based assessments can help researchers select the most appropriate tool for different research questions and populations. Questionnaires are generally more cost-effective and easier to administer to large groups of children, making them suitable for large-scale studies and surveillance (Triantafyllidis et al., 2021). Accelerometers, while more expensive, provide detailed information on the intensity, frequency, and duration of PA, which can be valuable for studying the specific effects of different types of activities on health outcomes (Idowu et al., 2024). By establishing a clear correlation between the two methods, researchers can confidently use questionnaires to estimate PA levels in situations where accelerometers are not feasible or practical while also using accelerometers to validate and refine questionnaire-based measures (Makai et al., 2023). This will ultimately lead to more accurate and comprehensive assessments of children's PA, contributing to a better understanding of the factors that influence their activity levels and the development of effective interventions to promote healthy behaviors.

Previous studies investigating the correlation between the PAQ-C and accelerometer-based data have yielded mixed results. Some studies have reported moderate correlations between PAQ-C scores and accelerometer-derived measures of PA, particularly for vigorous, moderate, or moderate-to-vigorous PA, while other studies have reported weaker correlations (Ben Jemaa et al., 2018; Marasso, Lupo, Collura, Rainoldi, & Brustio, 2021; Triantafyllidis et al., 2021). These variations highlight the importance of considering factors such as age, recall accuracy, and the specific type of PA being assessed when interpreting the correlation between the PAQ-C and accelerometer data. Specifically, an Italian study reported a moderate relationship (approximately 0.30–0.40) between the PAQ-C and accelerometer measurements (Marasso et al., 2021), which is similar to the correlations reported in an Austrian study (Cocca, Greier, Drenowatz, & Ruedl, 2021). While our study revealed correlations of 0.30–0.40 (please see Results for more details), this finding is clearly in line with previous research conducted with children of the same age (Cocca et al., 2021; Triantafyllidis et al., 2021).

We have found no evident difference in magnitude of the correlations between direct and indirect measurement of PA between genders, and this could be attributed to several factors. First, all the children attended the same school. Therefore, they are likely to experience similar environmental influences on their PA patterns. This includes factors such as access to school facilities, a physical education curriculum, and opportunities for active play during recess, which generally affect both boys and girls equally (Burchartz et al., 2021). This shared environment may contribute to more consistent reporting of PA behaviors in both genders, leading to similar correlations with the objective accelerometer data.

Second, previous studies suggest that the questionnaire itself is capable of capturing a reasonable representation of children's activity levels, regardless of gender. While some studies have reported variations in correlations based on age (Triantafyllidis et al., 2021), we have focused on children within a specific age range and school environment. This may have minimized potential discrepancies, leading to more consistent findings across genders. Additionally, the standardized administration of the PAQ-C within the school setting may have further reduced potential variations in interpretation or recall, contributing to the observed similarity in correlations. Indeed, as explained in the Methods section, all the children who responded to the PAQ-C in the standardized environment were identically supervised and instructed, which together probably reduced the measurement error to the minimum possible value and resulted in similar magnitude of correlations for girls and boys.

Third, conducting the study within the same relatively narrow period of the year minimized the influence of external factors that could have differentially affected PA levels and reporting accuracy between boys and girls. By controlling for seasonal variations, the study ensured that weather conditions did not disproportionately limit outdoor activities for either gender, which is regularly found to be a highly important factor of PA variations in school-aged children (Blanchette et al., 2021). This minimized potential discrepancies in activity levels that could arise from boys and girls having different preferences or opportunities for outdoor play in different weather conditions.

Furthermore, testing within the same period helped standardize school duties and extracurricular activities, which can significantly impact children's time and energy for PA. This ensured that neither boys nor girls were disproportionately affected by academic pressures or varying commitments to extracurricular activities, which could have influenced their reported or measured PA levels (Beets, Beighle, Erwin, & Huberty, 2009). This temporal consistency reduced potential confounding factors and probably contributed to a more accurate comparison of PA patterns between genders, leading to the observed similarity in correlations between questionnaire-based and accelerometer-based assessments among girls and boys. However, despite the similarity in correlation coefficients, some gender-specific relationships still exist.

The observed difference in correlation patterns between boys and girls, where PAQ-C scores aligned with vigorous activity in boys and moderate activity in girls, could stem from variations in how each gender perceives and reports PA. First, boys may be more likely to focus on and recall high-intensity activities, such as competitive sports or physically demanding games, which align with the vigorous activity captured by accelerometers. This could be influenced by societal expectations and gender stereotypes that associate masculinity with vigorous physical exert (Archer, 2022; Cárcamo, Moreno, & Del Barrio, 2021). More specifically, societal expectations and gender stereotypes significantly influence how boys perceive and engage in PA, often associating masculinity with vigorous physical exertion.

Indeed, the accelerometer data highlighting vigorous activity as a more significant determinant of overall PA (obtained by the PAQ-C) in boys aligns with existing research and societal norms. Boys often gravitate toward high-intensity activities such as competitive sports and physically challenging games, driven by biological factors such as higher testosterone levels and social expectations that link masculinity with vigorous exertion (Kretschmer et al., 2023). This emphasis on vigorous activity logically directly influences their overall PA. In girls, the accelerometer data indicating moderate activity as a key contributor to overall PA (as obtained by the PAQ-C) reflect a different activity pattern. Girls tend to engage in a wider range of activities, including those of moderate intensity, such as brisk walking, cycling, and recreational play (Kretschmer et al., 2023). This pattern may be influenced by social factors that encourage girls to participate in activities that promote social interaction and overall movement rather than solely focusing on high-intensity exertion.

Finally, our findings of significant differences in the PAQ-C and PA-vigorous scores, with both being greater in boys, directly support the previous explanation. The higher PAQ-C scores in boys suggest that they tend to report higher levels of overall PA, which aligns with their greater engagement in vigorous activities, as measured by accelerometers. In addition to being supportive of previous studies, where authors have regularly reported more vigorous PA in boys than in girls (Cohen, Williamson, & Han, 2021; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008), this convergence of findings reinforces the notion that societal expectations and gender stereotypes contribute to boys' perceptions and reporting of PA, leading them to emphasize vigorous activities that conform to traditional notions of masculinity. This highlights the importance of

considering these sociocultural influences when interpreting self-reported PA data and designing interventions for PA in both genders.

This study has several notable strengths. First, this is likely the first study in Croatia, and one of the rare in southeastern Europe, which employed a gender-specific approach to investigating the validity of the PAQ-C. This focus on gender differences contributes to a more comprehensive understanding of the factors that influence children's activity levels and reporting accuracy. Second, the standardized measurement protocol, with the same trained team conducting all the assessments, enhanced the reliability and consistency of the data. This minimized potential variations in the administration or interpretation of the PAQ-C and accelerometer data, strengthening the validity of the findings.

However, the study also has several limitations. As a cross-sectional study, it provides a snapshot of the relationship between PAQ-C and accelerometer data at a specific point in time, limiting the ability to draw conclusions about causality or changes over time. Additionally, this study focused on a specific region, which may limit the generalizability of the findings to other populations. Further research involving diverse samples and longitudinal designs is needed to confirm these findings and explore the broader applicability of the PAQ-C in different contexts.

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Conflict of interest

The authors declare that there are no conflict of interest.

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Conclusions

This study aimed to examine the gender-specific validity of the PAQ-C in assessing PA levels among urban Croatian children. Our findings reveal that the PAQ-C has similar and acceptable validity for both boys and girls in this population. However, we observed distinct patterns in the types of activities that correlated most strongly with the PAQ-C scores. In boys, vigorous-intensity activities were more strongly correlated, whereas in girls, moderate-intensity activities were more strongly associated with PAQ-C scores.

While the PAQ-C appears to be a valid tool for assessing overall PA levels in both genders, our findings highlight the importance of considering the specific types of activities that contribute to these scores. Future research could explore these gender-specific patterns in more detail, investigating the underlying factors that influence activity choices and preferences in boys and girls. This knowledge could inform the development of tailored interventions to promote PA and address potential gender disparities in activity levels.

Accurate assessment of PA is essential for understanding and promoting healthy lifestyles among young people. By acknowledging and addressing potential gender differences in activity patterns and measurement tools, we can develop more effective strategies to encourage PA and improve health outcomes for all children.

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