DOI 10.26773/smj.250213

SportMont

ORIGINAL SCIENTIFIC PAPER

Is the PAQ-C a Valid Measurement Tool for Evaluating Physical Activity Levels in Rural Children? Cross-Sectional Study in Southern Croatia

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Abstract

The physical activity level (PAL) of rural children has rarely been studied, especially considering the validity of measurement tools used for the evaluation of PAL. The aim of this study was to evaluate the criterion validity of the Physical Activity Questionnaire for Children (PAQ-C) in rural children from Croatia by comparing the data obtained via the PAQ-C to those recorded via direct measurement via accelerometers. The participants were 47 children from rural regions in southern Croatia who were simultaneously tested on the PAL directly, via GENEActiv triaxial accelerometers, and indirectly, via the PAQ-C. Gender-stratified Pearson's correlations and multiple regressions were calculated to evaluate associations between variables, whereas a t test was used to determine differences between genders in the study variables. Associations between direct and indirect measurements were weak (boys: R=0.08–0.29, p>0.05; girls: R=0.04–0.35, p>0.05). Boys had higher directly measured vigorous PAL (t test = 3.22, p<0.05) and PAQ-C (t test =2.04, p 0.05). The results revealed poor criterion validity of the PAQ-C in rural children. Therefore, more comprehensive and context-specific assessment indirect measurement tools that capture the diverse range of activities common in rural settings are needed.

Keywords: *prepuberty, school, living environment, type of physical activity, multiple regression*

Introduction

Physical activity is essential for early school-age children, as it supports physical, cognitive, and emotional development during this critical stage (Užičanin et al., 2024). Regular physical exercise strengthens muscles and bones, enhances motor skills, and improves cardiovascular health. It also plays a vital role in fostering concentration, memory, and academic performance by stimulating brain activity. However, when children start school, their daily habits often change (Peiris et al., 2022). They spend more time sitting in classrooms and have less time playing and moving around. This decrease in activity can lead to problems such as weight gain, poor posture, and lower fitness levels. At home, more screen time can make the problem worse by adding to their inactive lifestyle. Therefore, it is important to encourage active habits early because it becomes more difficult to change these behaviors as children grow older (Hrg, Lončar, Zelanto, Novak, & Podnar, 2023). By making movements a normal and enjoyable part of their school day, children can develop healthy habits that last a lifetime (Wang, Li, Liu, Zhang, & Luo, 2024). In doing so, the first prerequisite is the objective evaluation of physical activity level (PAL), since accurate assessment of PAL provides insights into whether children are meeting recommended physical activity guidelines (Montoye, 1996).

In general, the measurement tools used for the evaluation of the PAL can be divided into two groups: (i) direct/objective methods and (ii) indirect/subjective methods. Direct methods such as accelerometers and heart rate monitoring may provide detailed data on movement patterns, intensity, frequency, and

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duration of activity, making them highly reliable for capturing real-time information. Additionally, they eliminate subjective bias, making them ideal for scientific research and clinical assessments. However, they have limitations such as high costs, technical complexities, and the need for user compliance in wearing the devices properly. Additionally, data analysis from these devices often requires specialized software and expertise, posing additional challenges. Despite these drawbacks, direct methods remain the gold standard for precise and objective PAL evaluation (Barreira et al., 2015).

Indirect methods, such as questionnaires, are cost-effective and practical ways to evaluate PAL in large populations. They can be tailored to capture specific details, such as activity types, preferences, and contextual factors (e.g., seasonal variations or family involvement). Questionnaires are easy to administer and require minimal training, making them accessible for schools, community programs, and public health surveys (Sunda, Gilic, & Bascevan, 2022). However, they rely heavily on self-reported data, which are prone to recall bias, social desirability bias, and inaccuracies—especially in children, who may struggle to remember or estimate their PAL. Furthermore, indirect methods provide less precise data and may lack consistency when comparing different populations or studies. However, they are valuable for gathering subjective information that complements objective measurements (Cuberek, Janikova, & Dygryn, 2021).

The living environment plays an important role in the PAL of children, especially if we observe differences between urban and rural communities. While it may seem that children in rural communities are naturally more active due to their surroundings, research suggests that this is not always the case (McCulloch, Koopmans, & Pelletier, 2005; Prochnow, Umstattd Meyer, Bridges Hamilton, & Pollack Porter, 2020). Meanwhile, evaluating PALs in rural children is essential because their activity patterns are often distinct from those of urban children. Rural children typically engage in activities tied to agriculture, household chores, or outdoor play, which are irregular and context specific. Standard measurement tools and protocols, designed primarily for urban populations, may fail to accurately capture these unique activity patterns. Questionnaires may overlook nontraditional activities, whereas accelerometers may not adequately differentiate between tasks such as manual labor and recreational movement. Additionally, rural settings often lack structured sports or exercise programs, requiring tailored evaluation methods to account for informal and spontaneous activities. Therefore, it is crucial to develop or adapt measurement tools that reflect the realities of rural life, ensuring accurate and meaningful assessments of PAL in this population.

The comparison of questionnaires and accelerometer-based reports in evaluating physical activity levels is a crucial area of research, especially in rural populations where physical activity patterns may differ significantly from those in urban settings (Larouche et al., 2024). While the strengths and limitations of both methods are well documented, there are limited data on their comparability, particularly in rural settings. Additionally, comparability of these methods has rarely been studied in southeastern Europe, whereas we have found no study where criterion-related validity of the questionnaire-based reports of PAL is studied in rural children from this region. Therefore, the main objective of this study was to evaluate the gender-specific criterion-related validity of the Physical Activity Questionnaire for Children (PAQ-C) in comparison to accelerometer-based directly measured physical activity in rural children from southern Croatia. The authors believe that one of the major strengths of this study is its focus on rural children, who often engage in unique, context-specific physical activities that may be underrepresented in standardized questionnaires. By including both methods, the study provides a dual perspective—quantitative insights from accelerometers and qualitative context from questionnaires—offering a more holistic understanding of activity patterns. Initially, we hypothesized that this study would confirm the validity of the PAQ-C in the evaluation of PAL in rural children, irrespective of sex.

Materials and methods

Participants

A total of 47 children from rural region in southern Croatia (Imotski region) participated in the study (16 girls). At the time of data collection, all participants were between 8 and 10 years old, were in the 3rd or 4th grade of primary school, were in good health, and were regularly participating in physical education (PE) classes. Children who were ill or had musculoskeletal injuries during the study period were excluded from participation. Prior to the study, parents/guardians received detailed information from the research team about the study's aims and procedures, and they provided written informed consent for their children's participation. The study was approved by the Ethics Committees of the Faculty of Kinesiology, University of Split, and the University of Zagreb.

Variables and measurement

In addition to age (in years) and gender (male or female), which are recorded on the basis of school records, in this study, we directly and indirectly evaluated PAL. The PAL was directly measured by a GENEActiv accelerometers (Activinsights Ltd., Cambridge, UK). The GENEActiv accelerometer is a triaxial device equipped with a seismic acceleration sensor. It is compact (36×30×12 mm), lightweight (16 g), waterproof, and provides body temperature data to enhance the validation of energy expenditure and nonwear time detection. GENEActiv has been previously described in detail and is one of the most widely used accelerometers for assessing physical activity, sedentary behavior, and sleep characteristics (Clark et al., 2018; Esliger et al., 2011). The participants wore the accelerometer on their nondominant wrist continuously, 24 hours per day. GENEActiv data were downloaded via GENEActiv PC software version 2.2 and saved in raw format as .bin files. These files were subsequently analyzed via the R package GGIR version 1.2-0 (Van Hees et al., 2014). The results obtained were expressed in minutes spent in sedentary behavior, as well as minutes engaged in low, moderate, and vigorous levels of physical activity. The variables we observed were the number of steps performed (STEPS), sedentary time, light PA (PA-light), moderate PA (PA-moderate), and vigorous PA (PA-vigorous).

The PAQ-C Croatian version, a questionnaire designed to assess PAL in children aged 8--14, was developed to measure overall habitual physical activity (Samaržija & Mišigoj-Duraković, 2013). It consists of 9 items, each rated on a 5-point Likert scale, with questions evaluating various aspects of physical activity engagement, for example, "In the last 7 days, what did you mostly do during a long break (except eating a snack)?" and "In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running,

jumping, throwing)?". The overall physical activity score was obtained by calculating the average of all the responses. A maximum PAQ-C score of 5 indicates a high level of physical activity, whereas a score of 1 signifies very low or no physical activity.

Statistics

The Kolmogorov–Smirnov test was used to confirm that the data followed a normal distribution, a key assumption for many statistical tests. Means and standard deviations were calculated to provide a basic overview of the data characteristics. Independent samples t tests were used to explore potential differences in physical activity data between boys and girls. Pearson's correlation coefficients were calculated to assess the relationships between variables, and correlations were interpreted on a scale ranging from 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. Multiple regression analyses were conducted to examine the complex relationships between accelerometer-based PAL data and self-reported PAL (PAQ-C). A forward stepwise approach was employed to address potential collinearity among predictor variables. While acknowledging that accelerometer-based data could ideally be the criterion in the regression analyses, the number of accelerometer-derived variables compared with the single PAQ-C variable made this approach impractical. Therefore, we proceeded with accelerometer data as predictors and the PAQ-C score as the criterion.

Results

The correlations between the PAQ-C score and the accelerometer-derived variables for the total sample are presented in Figure 1. Evidently, the PAQ-C was significantly associated only with PA-vigorous (R=0.31, weak correlation), whereas other accelerometer-derived variables were not significantly correlated with the PAQ-C in the total sample (not dividing boys and girls).

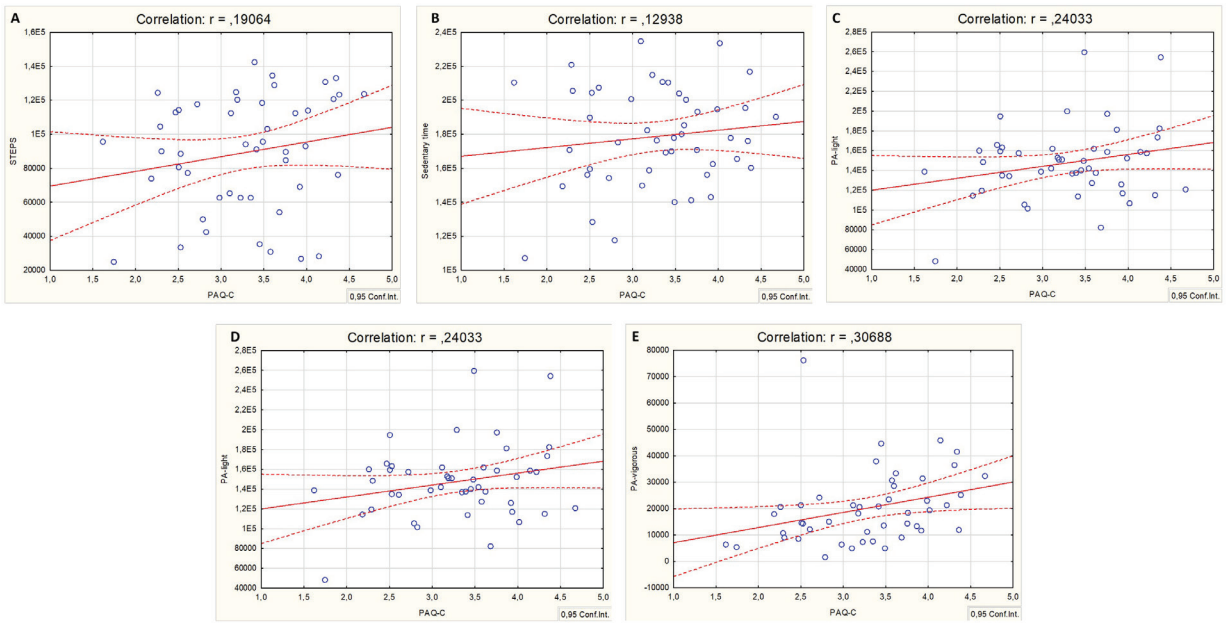

FIGURE 1. Correlations between Physical Activity Questionnaire (PAQ-C) and accelerometer measurements in rural children (A – Steps; B – sedentary time, C – light physical activity, D – moderate physical activity, E – vigorous physical activity)

Table 1. Pearson's correlations between data derived by indirect and direct measurement of physical activity in boys and girls (* indicates statistical significance of p<0.05)

	PAQ-C	STEPS	Sedentary time	PE-light	PE-moderate
Boys (n = 24)					
STEPS	0.20				
Sedentary time	0.28	0.35			
PA-light	0.29	0.39*	0.17		
PA-moderate	0.08	0.29	0.03	0.38*	
PA-vigorous	0.23	-0.10	-0.17	0.06	0.52*
Girls (n = 16)					
STEPS	0.14				
Sedentary time	-0.19	-0.22			
PA-light	0.35	0.41	-0.24		
PA-moderate	0.18	0.79*	-0.47	0.23	
PA-vigorous	0.05	0.51*	-0.03	0.00	0.42

Table 2. Multiple regression analysis for criterion Physical Activity Questionnaire for Children (forward stepwise model) in boys and girls

	Boys (n = 26)		Girls (n = 14)	
	Beta	**p**	**Beta**	**p**
Sedentary time	0.30	0.10		
PA-light	0.30	0.12	0.35	0.18
PA-moderate	-0.25	0.27		
PA-vigorous	0.39	0.07		
Multiple R	0.49		0.35	
R^2	0.24		0.13	
p	0.11		0.18	

Legend: R^2- coefficient of determination, Beta – standardized regression coefficient

Table 2 presents the correlations between accelerometer-derived data on PAL and the PAQ-C for boys and girls. Among boys, the PAQ-C was not significantly correlated with any of the accelerometer-based data, with weak correlations between the PAQ-C score and sedentary time (R=0.29, p>0.05), PA-light (R=0.28, p>0.05), and PA-vigorous (R=0.23, p>0.05) scores. The correlations between the PAQ-C score and direct measurement of the PAL score did not reach statistical significance in girls, with a moderate correlation between the PA-light score and the PAQ-C score (R=0.25, p>0.05).

The results of the multiple regressions for the PAQ-C criterion revealed no significant multivariate associations between predictors (accelerometer-derived data) and criterion in boys (R2=0.25, p>0.05) or girls (R2=0.12, p>0.05) (Table 2).

When the PAL variables of girls and boys were compared, significant differences (p<0.05) were found for the PAQ-C and PA-vigorous. For both variables, boys achieved higher results than girls did (t test =2.04 and 3.22, for the PAQ-C and PA-vigorous, respectively) (Table 3).

Table 3. Descriptive statistics and t-test differences between boys and girls in study variables (PA – physical activity)

	Boys		Girls		t-test	
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p**
PAQ-C (score)	3.4	0.80	3.0	0.48	2.05	0.05
STEPS (min/day)	12899.9	5337.85	12466.3	3668.52	0.29	0.77
Sedentary time (min/day)	422.3	66.69	432.0	76.93	-0.45	0.65
PA-light (min/day)	342.7	88.31	368.3	88.87	-0.94	0.35
PA-moderate (min/day)	172.1	46.38	179.5	39.64	-0.55	0.59
PA-vigorous (min/day)	58.2	35.34	28.4	14.59	3.22	0.00

Discussion

With respect to the study aims, the results revealed several important findings. First, the criterion-related validity of the PAQ-C in rural settings is questionable. Second, correlations between questionnaire-based and accelerometer-based evaluations of PAL are dissimilar across genders, with stronger correlations evidenced for boys. Finally, gender differences in the questionnaire-based evaluation of PAL were evidently related to greater vigorous physical activity in boys.

As already mentioned in the introduction, there is no doubt that PALs in rural children often differ significantly from those in their urban counterparts. Rural environments may provide unique opportunities for unstructured play, such as exploring natural surroundings, engaging in farm chores, and participating in outdoor activities. Compared with those of urban children, these activities can contribute to higher levels of cardiorespiratory fitness and speed-agility (Sylejmani et al., 2019). However, rural children may also face challenges, including limited access to organized sports, recreational facilities, and safe spaces for play (Sekulic, Blazevic, Gilic, Kvesic, & Zenic, 2020). This can lead to lower overall PALs and potential disparities in participation rates compared with those of urban children. Additionally, the types of physical activity available to rural children may be more seasonal and weather dependent, further influencing their activity patterns.

Moreover, the PAQ-C questionnaire includes items related to various physical activities, such as active play, organized sports, and physical activity, whereas only a small number of items are oriented toward "nonstructured" activities characteristic of rural settings (Sekulic, Rodek, & Sattler, 2020; Šipalo Lilić, 2024). Therefore, the PAQ-C may not fully capture the unique and diverse range of activities common in rural settings. For example, the questionnaire may not adequately account for activities such as farm work, horseback riding, fishing, hunting, or exploring natural environments, which can contribute significantly to PAL in rural children. Additionally, the PAQ-C may not fully capture the unstructured and spontaneous nature of play, which is often characteristic of rural environments. This potential underrepresentation of rural-specific activities could lead to an underestimation of actual PALs in these children.

On the other hand, accelerometers provide a more objective and comprehensive measure of PAL than self-report questionnaires such as the PAQ-C do, especially in ru-

ral settings where activity patterns can be diverse and less structured (Lynch et al., 2019). Specifically, accelerometers capture movement data continuously, providing a more accurate representation of overall PAL irrespective of the activity type. This is particularly important for rural children who may engage in activities not explicitly included in the PAQ-C (i.e., home duties, outdoor play in natural environments, or intermittent bursts of activity throughout the day). Accelerometers generally capture the intensity, frequency, and duration of these activities, regardless of their specific type or location. Taken together, these discrepancies in data capture probably contributed to the poor correlation observed between PAQ-C scores and accelerometer-based measures in the studied rural children.

Despite the relatively low correlation between the PAQ-C and accelerometer-based data in rural children, the correlations were evidently higher in boys than in girls. Several factors could contribute to such results. First, differences in cognitive processing between boys and girls could contribute to variations in their ability to recall physical activities. In other words, boys may be more likely to engage in vigorous activities that are inherently more memorable because of their higher intensity and potential for excitement (Dilley, Zou, & Loprinzi, 2019). These activities, such as running, jumping, or competitive sports, might leave a stronger impression in their memory than might less intense activities, which could contribute to an even stronger correlation between indirect and direct measurement of PAL in boys.

Furthermore, social expectations and gender norms could influence how boys perceive and prioritize physical activity. Specifically, social expectations and gender norms can significantly shape how boys perceive and engage in physical activity, often steering them toward activities associated with masculinity and physical prowess (Garcia, Pender, Antonakos, & Ronis, 1998). From a young age, boys are often encouraged to participate in competitive sports and activities that emphasize strength, speed, and aggression, whereas activities such as dance or gymnastics might be perceived as less masculine. This can lead to a greater focus on activities that align with traditional notions of masculinity, potentially influencing their choices and preferences in physical activity. These expectations can also affect how boys perceive their own physical abilities and body image, with greater emphasis placed on physical strength and athleticism as markers of masculinity (Lago-Ballesteros, García-Pascual, González-Valeiro, & Fernández-Villarino, 2021). Consequently, boys may prioritize activities that allow them to demonstrate these qualities, further reinforcing the influence of gender norms on their physical activity patterns, which could contribute to their better recall of these specific types of activities, which often align with the items included in the PAQ-C.

Finally, the PAQ-C, with its emphasis on sports participation, may not accurately reflect the PAL of girls in rural settings because of their lower degree of involvement in organized sports. Girls often face barriers to sport participation, including limited opportunities, social expectations, and a lack of confidence, which is particularly the case in rural settings where the availability of "girl-oriented sports" is a known issue (Eime, Payne, Casey, & Harvey, 2010). This can lead to an underrepresentation of their actual PAL when assessed via the PAQ-C, which focuses primarily on activities such as team sports and individual athletic pursuits. As a result, rural girls who engage in other forms of physical activity may not receive adequate credit for their activity levels on the PAQ-C. This discrepancy may contribute to the lower correlation observed between PAQ-C scores and accelerometer data in girls, as the questionnaire fails to capture the full range of their physical activities.

Most of the previously discussed issues that could explain the stronger correlations between direct and indirect measurements in boys even explain the differences between genders in the PAQ-C. First, the higher PAQ-C scores observed in rural boys than in girls could be attributed to several interconnected factors. First, boys may be more likely to engage in vigorous physical activities that are easier to recall and align with the items included in the PAQ-C (Dilley et al., 2019). These activities, such as competitive sports, rough-and-tumble play, and physically demanding chores, might leave a stronger impression in their memory and be more readily reported on the questionnaire. Additionally, social expectations and gender norms could influence how boys perceive and prioritize physical activity, potentially leading to a greater focus on activities traditionally associated with masculinity and physical prowess (Garcia et al., 1998). Irrespective of differences in PAL itself (please see further discussion on gender differences in accelerometer-derived data), this could further contribute to their higher PAQ-C scores, as the questionnaire primarily captures activities such as sports and structured exercise that are often encouraged for boys.

Furthermore, boys might exhibit a stronger tendency toward visual-spatial processing, which could enhance their ability to remember activities with distinct visual and spatial components (Tzuriel & Egozi, 2010). This could make it easier for them to recall and report activities involving movement and location, such as playing sports or engaging in outdoor games. Finally, boys may be more likely to overestimate their PAL due to social desirability bias, as physical activity is often associated with positive attributes such as strength and competitiveness in boys. This tendency to overreport could contribute to the higher PAQ-C scores observed in boys than in girls.

While the PAQ-C scores indicated higher perceived physical activity levels in boys, the accelerometer data confirmed this trend by objectively demonstrating that boys indeed engage in more vigorous physical activity than girls do. The confirmation of higher vigorous physical activity in rural boys through accelerometer data aligns with existing research that suggests that biological factors might contribute to this difference. Specifically, boys tend to have a greater proportion of lean muscle mass and greater cardiovascular capacity, which can enhance their ability to engage in vigorous activities (Ayyavoo, Derraik, Hofman, Biggs, & Cutfield, 2014). Importantly, the already said limited availability of girl-oriented sports in rural settings can significantly impact their opportunities to engage in vigorous physical activity. Rural communities often have fewer resources and infrastructure for organized sports, and the available options may be focused predominantly on traditionally male-dominated sports such as football and martial arts. Since the authors of this study have been actively involved in youth sports for more than a decade, they can witness that the specified problem exists in the studied region as well. In conclusion, this

lack of diverse options can discourage girls from participating in sports and limit their access to activities that promote vigorous physical activity, resulting in the differences we have demonstrated herein.

This study has several limitations and strengths. First, the cross-sectional nature of the study limits the ability to draw causal inferences about the relationships between variables. Also, the relatively small sample size and focus on a single rural region may limit the generalizability of the findings to other populations. However, this is one of the first studies to examine this specific problem in southeastern Europe, providing valuable insights into a previously under-researched area. Also, it is likely the first study of its kind in Croatia, contributing important knowledge to the understanding of this issue within the country, and in surrounding countries with similar socio-cultural context of sport and physical activity.

Conclusion

This study highlights the limitations of the PAQ-C in accurately assessing PAL in rural children, particularly among girls. The findings underscore the need for more comprehensive and context-specific assessment tools that capture the diverse range of activities common in rural settings. Future research should focus on developing and validating questionnaires that are tailored to the unique needs and characteristics of rural populations, considering factors such as seasonal variations, access to organized sports, and cultural norms related to physical activity.

The observed gender differences in both perceived and actual PALs emphasize the importance of considering gender-specific factors when designing interventions to promote physical activity in rural children. Boys' greater engagement in vigorous activities and their potential overestimation of PAL suggest the need for targeted strategies that address social desirability bias and encourage a broader range of physical activities. For girls, addressing barriers to sport participation and providing more diverse opportunities for organized and unstructured physical activity are crucial. This may involve promoting nontraditional sports, creating safe and accessible spaces for play, and challenging gender stereotypes that limit girls' engagement in physical activity.

Acknowledgments
There are no acknowledgments.

Conflict of interest
The authors declare that there are no conflict of interest.

Received: 15 December 2024 | **Accepted:** 20 January 2025 | **Published:** 01 February 2025

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