VALIDITY AND RELIABILITY OF THE INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE-SHORT FORM IN ADOLESCENTS

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Original scientific paper
DOI 10.26582/k.56.2.10

Abstract:

A very few studies examined the validity and reliability of the International Physical Activity Questionnaire-Short Form (IPAQ-SF) in the adolescent population**,** and no study has been conducted in Serbia. The aim of this study was to examine the validity and reliability of the IPAQ-SF in adolescents. The cross-sectional study included 101 adolescents aged 15-19 years (31.8% boys, 68.2% girls). The study instrument was a questionnaire regarding demographic characteristics, physical activity, and iPhone built-in pedometer. The data were analyzed using the interclass correlation coefficient (ICC), Spearman correlation coefficient, exploratory factor analysis (EFA) with promax rotation, and two confirmatory factor analyses (CFA) to examine theoretical factor model and for the two-factor model based on the EFA. Total activity measured by IPAQ-SF correlated weakly but significantly with the pedometer measured steps (r=0.25, p=.045). The EFA showed two factors that explained 64.19% of the variance (46.15% and 18.05%). The CFA for the two-factor model showed acceptable fit, and for the three-factor model better fit GFI 0.951, AGFI 0.827, CFI 0.934, RMSEA 0.131 (95% CI: 0.07-0.198). Poor to moderate reliability was observed with ICC (0.36-0.65). Our study shows that the IPAQ-SF has a good validity and acceptable reliability in the population of adolescence, and has numerous advantages, especially in the population studies, but it requires caution in the interpretation of the results.

Key words: *IPAQ-SF, physical activity, adolescents, iPhone Health App, pedometer, validity*

Introduction

Regular physical activity (PA) has many health benefits. PA has a preventive effect on chronic non-communicable diseases, such as cardiovascular diseases, hypertension, type 2 diabetes mellitus, obesity, cancer, and metabolic syndrome (Bhatt, 2016; Lavie, Ozemek, Carbone, Katzmarzyk, & Blair, 2019). It has a positive effect on social and psychological status, improves the quality of life, and reduces costs of the healthcare (Wang, et al., 2023). Insufficient PA is associated with 20-30% increased risk of all-cause mortality (WHO, 2022). Older adolescents (18-19 years old) are less physically active than younger ones (15-16 years old) (Djurdjevic, Nikolic, Mazic, & Sipetic-Grujicic, 2023). Adolescents with obesity have an increased risk of being obese in adulthood, and a higher risk of developing chronic non-communicable diseases. In addition, insufficient PA during adolescence is associated with the development of depression and destructive behavior, poorer social life and school success (Asigbee, Whitney, & Peterson, 2018).

According to the World Health Organization (WHO) and the National Health Service (NHS), the recommended daily PA for adolescents is 60 minutes of moderate to vigorous PA together with exercises to strengthen the musculoskeletal system at least three times a week, and flexibility exercises at least twice a week (NHS, 2019; WHO, 2020). WHO data show that about 80% of adolescents do not meet the recommendations for PA (WHO, 2020).

Researchers and health care professionals need accurate data on PA in order to better understand PA behavior and develop programmes for the improvement of PA levels in this population. To obtain accurate data, it is necessary to use a valid instrument. PA can be measured objectively and subjectively. Among the objective measures of PA, the most commonly used instruments are accelerometers and pedometers (Ramakrishnan,

et al., 2021). Among subjective measures of PA, the most commonly used instruments are questionnaires (Sember, et al., 2020). Accelerometers are used as a standard in PA estimation, but due to their cost, they are not suitable for use in large-scale studies. In addition, the pedometer is a valid instrument for community based studies, cheaper than an accelerometer, easier to use, but has limitations in measuring slow walking (<0.6m/s), in swimming, cycling, for people with abnormal gait patterns, and people who are obese (Ehrler, Weber, & Lovis, 2016; Keating, et al., 2019).

The technological development and the increasing possibilities provided by smartphones have made it easier to monitor PA and health behavior. In 2023, 6.92 billion (86.29%) of the world's population used smartphones (Bankmycell, 2023). In addition to the usual features, smartphones have a built-in gyroscope, compass and triaxial accelerometer, with very similar specifications to the accelerometers used in PA monitoring (Romeo, et al., 2019). Modern iPhone models, starting in 2013 and iPhone 5s model, unlike other smartphone manufacturers have a built-in M (motion) coprocessor, which is responsible for processing data related to PA (Apple, 2013). Some studies have shown that just having the pedometer app increases the total number of steps taken (Romeo, et al., 2019; Sullivan & Lachman, 2017). To monitor and encourage PA, Apple has developed the Health App. Due to these hardware and software characteristics, it is possible to monitor movement, energy consumption, intensity, number of steps, elevation, sleep, etc. All this makes the iPhone a valid and reliable instrument, which can be used as a valid replacement for the pedometer and accelerometer (Höchsmann, et al., 2018; Major & Alford, 2016; Nolan, Mitchell, & Doyle-Baker, 2014).

Many researchers opt for using questionnaires over the objective measures as they are easy to use, and the studies are of lower cost. Among the questionnaires developed so far for the measurement of PA, the most commonly used is the International Physical Activity Questionnaire-Short Form (IPAQ-SF). In some studies, this method has been shown to be less accurate due to its self-reported nature, language-specificity, susceptibility to bias and most often overestimation of PA (Fillon, et al., 2022; Rääsk, et al., 2017). Validity and reliability of the IPAQ-SF has been verified in many studies in the adult population (Sember, et al., 2020). However, validity and reliability of the IPAQ-SF in adolescents is less known. To the best of our knowledge, only four studies examined the validity and reliability of the IPAQ-SF in this population, i.e., investigating participants that in some part belonged to the age of high school students aged 15-19 years (Lachat et al., 2008; Monyeki, Moss, Kemper, & Twisk, 2018; Rangul, Holmen, Kurtze, Cuypers, & Midthjell, 2008; Wang, Chen, & Zhuang, 2013), and no study has been conducted in Serbia.

The aim of this study was to examine the validity and reliability of the IPAQ-SF in adolescents 15-19 years old for the measurement of PA, and to compare the results from IPAQ-SF with the number of steps measured by an iPhone smartphone recorded in the Health App.

Methods

A total of 101 adolescents (36 boys, 65 girls), 15-19 years old, were included in the study conducted during January 2020. The research targeted students from two high schools in Valjevo, a key administrative hub of the Kolubara district in western Serbia. Specifically, students from Valjevo High School and the Medical School were considered for participation. To be eligible, students needed to meet two requirements: they had to be present at school during the designated recruitment week and possess an iPhone. Only those who met these criteria were contacted and invited to participate in the study. Targeting Valjevo High School and the Medical School allowed researchers to work with a practical and manageable sample that is likely representative of students in the Kolubara district. These schools' curricula emphasize physical activity and healthcare, which may enhance students' interest and engagement in the study, unlike other vocational schools, thereby potentially improving the quality of the data collected. Participants who lacked one or more values, or who answered "I don't know," were excluded from the analysis. The analysis included only participants with the complete data, and our final sample included 66 participants.

Information about the study and the study protocol were submitted to the School Board and then to the Parents Council, who approved the research, after which the parents gave their consent for the children's participation in the study. This study was approved by the Ethical Committee of the Faculty of Medicine, University of Belgrade (No: 29/XII-18).

Data collection

The data were collected through the questionnaire which consisted of two sections: demographic characteristics (gender, age, school, grade, housing), and current physical activity level (IPAQ-SF). The data from the iPhone Health App, as a pedometer, was recorded along with the anthropometric measures (height, weight, waist circumference).

IPAQ-SF

The assessment of PA was done through the modified and translated Serbian version of IPAQ-SF. Modification and translation were done in three phases: backward translation, forward trans-

lation and pilot testing (kappa ≥ 0.90) (Todorovic, et al., 2019). IPAQ-SF consists of seven questions through which the level of physical activity and sitting time in the previous seven days are assessed. Participants were asked to record how many days a week they engage in PA (vigorous PA, moderate PA, walking) and how many hours and minutes, as well as how much time they spend sitting. All data from the survey were processed in order to calculate energy expenditure expressed in MET-min/week (Harraqui, et al., 2023). Only those activities that lasted at least 10 minutes were considered. Energy expenditure (in MET minutes per week) was calculated as a sum of energy expenditure in all activities (in MET-min/week in each of the activities—vigorous PA [VPA], moderate PA [MPA] and walking). The energy expenditure in each of the activities was calculated as number of days of activity*number of minutes/day of activity*k. K values used were the values recommended for IPAQ scoring: 3.3 METs for walking, 4 METs for moderate activity, and 8 METs for vigorous activity (Harraqui, et al., 2023).

iPhone Health App (pedometer)

Using the iPhone, built-in triaxial accelerometer and motion co-processor in the phone, the number of steps taken was recorded through the Health App system application. As there is no manufacturer's recommendation on the specific location of the iPhone to be worn while moving, we used finding from the study by Hochsmann et al. (2018) showing that the position of the phone does not affect the accuracy of the step measurement. All participants were told to keep their phone in their trousers pocket when moving, being the most common place to carry a phone. It was emphasized to them that they should carry the phone every time they moved. The reliability and validity of the iPhone in measuring steps taken has been tested in the population (Case, et al., 2015; Höchsmann, et al., 2018; Nolan, et al., 2014), so it was chosen for its practical use to estimate the number of steps.

Anthropometric measurements

Body height was measured with an accuracy of 0.1 cm using an altimeter SECA 213 (Seca GmbH &Co.KG.), and body mass with an accuracy of 0.1 kg using Tanita smart scale RD-953 (Tanita Corporation, Japan). Waist circumference was measured with a measuring tape (cm) in the middle between the lower rib arch and the iliac bone. Participants were barefoot and in sportswear. After measuring height, weight and waist circumference, body mass index (BMI) (kg/m^2) was calculated as the ratio of weight (kg) and square of height (m^2). Also, WHtR was calculated as the ratio of waist circumference (cm) and height (cm).

Data analysis

Descriptive statistics are expressed as mean±SD and percentages. Student's independent t-test was used to assess differences between the normally distributed continuous variables. The differences between the continuous variables without normal distribution were assessed using Mann-Whitney U test. Chi-square was used for categorical variables. The interclass correlation coefficient (ICC) was used to assess the test-retest reliability of the IPAQ-SF. Spearman correlation coefficients were used to assess the correlation of the IPAQ-SF data (MET-min·wk^{-1}) and the steps taken by the iPhone Health App. Exploratory factor analysis (EFA) with promax rotation was done to explore the factor structure based on the original construct. Two confirmatory factor analyses (CFA) were done. The first was to examine the theoretical factor model with three scales of IPAQ-SF. The second was for the two-factor model based on the exploratory factor analysis. Confirmatory factor analyses were done using AMOS 22 (IBM Corp). Data analysis was done using IBM SPSS Statistics analysis software (v.22.0 for Mac, Chicago, IL, USA).

Results

The participants were mostly girls (68.2%). There were no significant differences between the sexes in age, participation in relation to school, school grade and housing. Girls had significantly lower BMI and WHtR (Table 1).

Measured by the IPAQ-SF, the participants had a total PA of 3526.5±2838.1 MET-min·wk^{-1}, and the number of steps taken measured with a pedometer 42,194.9±15,741.2. During physical activity, the highest energy expenditure in MET-min·wk^{-1} was during walking. Energy expenditure while walking participated with 52% of total energy expenditure (excluding sitting). After walking, the highest estimated energy expenditure was recorded during VPA, expressed in MET-min·wk^{-1}. The total number of steps per week varied between 10,930 and 74,077 (Table 2).

The EFA showed two factors that explained 64.19% of the variance. The first factor explained 46.15% of the variance and the second 18.05%.

The factor loadings for each item are presented in Table 3.

The CFA for the traditional three-factor model showed GFI 0.951, AGFI 0.827, CFI 0.934, RMSEA 0.131 (95% CI: 0.07-0.198). The CFA for the traditional three-factor model is shown in Figure 1. The CFA for the two-factor model showed that GFI was 0.895, AGFI 0.724, CFI 0.788, RMSEA 0.203 (95% CI: 0.152-0.258).

Table 4 shows the reliability of IPAQ-SF through intraclass correlation coefficient (ICC). The ICC of all domains ranged from 0.36-0.65. It was highest

Table 1. Descriptive characteristics of participants (means ± SD and percentages)

	Boys (n=21; 31.8%)	Girls (n=45; 68.2%)	p*
Age (year)	17.1 ± 1.1	16.8 ± 0.9	.21
Height (cm)	184.2 ± 5.9	167.6 ± 5.9	<.001
Weight (kg)	80.03 ± 9.5	59.6 ± 8.6	<.001
Body mass Index (kg/m^2)	23.54 ± 2.16	21.23 ± 2.83	.002
Waist circumference (cm)	88.7 ± 7.7	74.7 ± 8.6	<.001
Waist-to-height ratio	0.48 ± 0.04	0.45 ± 0.05	.007
School (%) Valjevo High School Medical school	 71.4 28.6	 64.4 35.6	 .779
School grade[a] (%) 1st (USA 9th) 2nd (USA 10th) 3rd (USA 11th) 4th (USA 12th)	 14.3 4.8 42.9 38.1	 4.4 33.3 37.8 24.4	 .53
Housing (%) Living with both parents Living with one parent Living with foster parents	 85.7 14.3 0 (0)	 75.6 22.2 2.2	 .573

Table 2. IPAQ-SF and pedometer activity of participants (means ± SD and median)

	Boys (n=21)		Girls (n=45)		Total (N=66)		
	Mean ± SD	Median (range)	Mean ± SD	Median (range)	Mean ± SD	Median (range)	p*
IPAQ-SF (MET-min·wk^{-1})							
Vigorous activity	1557.1±1734.9	1200 (0-5040)	1069.3±1715.4	0 (0-6720)	1230.9±1724.8	160 (0-6720)	0.269
Moderate activity	637.1±805.9	360 (0-2940)	365.3±619.4	0 (0-3000)	451.8±689.8	0 (0-3000)	0.137
Walking	1923.4±1577.8	1188 (198-5544)	1806.6±1355.5	1386 (33-5544)	1843.7±1418.7	1386 (33-5544)	0.758
Sitting	3333.3±998.4	3360 (1260-5040)	3526.4±875.9	3360 (2100-5880)	3465±913.4	3360 (1260-5880)	0.428
Total activity (excluding sitting)	4137.7±3117.9	3359 (198-10371)	3241.2±2686.8	2376 (311-10932)	3526.5±2838.1	2742 (198-10932)	0.235
Pedometer (steps per week)	47536.2±13963.1	47923 (27851-74077)	39702.3±16045.4	34172 (10930-72804)	42194.9±15741.2	40416 (10930-74077)	0.059

Note. *p values ($p<.05$) for comparison between genders; IPAQ-SF – International Physical Activity Questionnaire–Short Form.

Table 3. PCA with equamax rotation with the Kaiser normalization

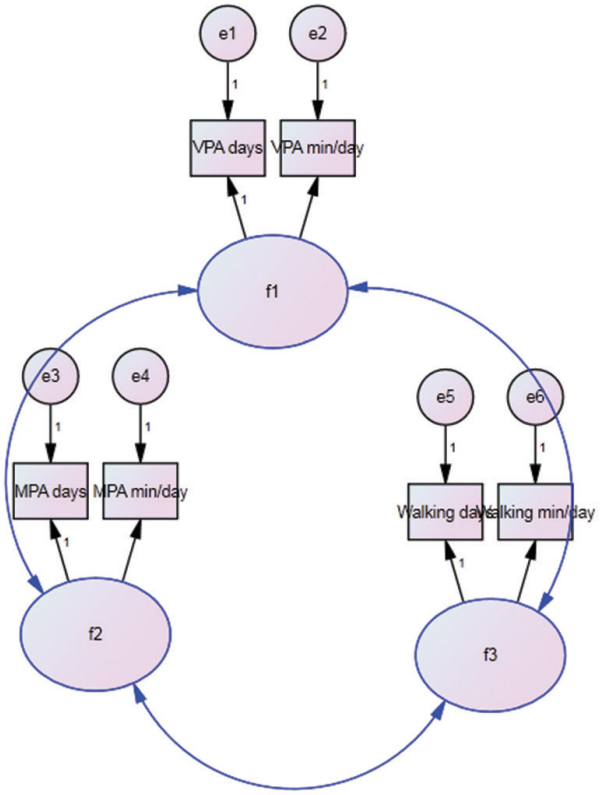
Item	Factor 1	Factor 2
Days in VPA	0.835	
Minutes/day in VPA	0.755	
Days in MPA	0.758	
Minutes/day in MPA	0.866	
Days walking		0.581
Minutes/day in walking		0.846

Note. PCA – principal component analysis.

Table 4. Test-retest reliability of the IPAQ-SF (MET-min·wk^{-1})

IPAQ-SF (MET-min·wk^{-1})	Intraclass coefficient (95% CI)	p
Vigorous activity	0.65 (0.49-0.77)	<.001
Moderate activity	0.55 (0.35-0.69)	<.001
Walking	0.36 (0.13-0.55)	.001
Sitting	0.56 (0.38-0.71)	<.001
Total activity (excluding sitting)	0.57 (0.39-0.71)	<.001

Note. IPAQ-SF – International Physical Activity Questionnaire–Short Form.



Note. CFA – confirmatory factor analysis.

Figure 1. The path diagram for the three-factor CFA.

for vigorous activity (0.65, 95% CI: 0.49-0.77) and lowest for walking (0.36, 95% CI: 0.13-0.55).

The median of PA and Spearman correlation coefficient between the IPAQ-SF (MET-min·wk^{-1}) and pedometer (steps/week) are presented in Table 5. Walking measured by the IPAQ-SF and the number of steps taken by pedometer had a relatively weak correlation, but significant (r_s = 0.25, p=.045). No significant correlation was found between other IPAQ-SF variables and by the pedometer measured number of steps. The correlation between energy expenditure measured by IPAQ-SF (total energy expenditure, energy expenditure in walking, energy expenditure in VPA, energy expenditure in MPA) and the number of steps/week is shown in Table 5.

Discussion and conclusions

Assessment of PA is very important in the adolescent population, as more than three-quarters of them do not meet WHO's recommendations on minimal PA (WHO, 2020). One of the most practical instruments that can be used in comprehensive studies assessing PA is the IPAQ-SF, so the aim of this study was to examine validity and reliability of the Serbian version of IPAQ-SF and to determine if there is a correlation between the subjective (IPAQ-SF) and objective measurement of PA (Health App—pedometer).

Our study showed that the average number of steps per week was just over 40,000 steps, which is almost a half of the expected number of steps for adolescents (Caillaud, et al., 2022). The recommendation by the World Health Organization for PA of adolescents states that adolescents need at least 60 minutes of moderate intensity PA each day and muscle strengthening exercises at least three times a week, which can roughly be translated in the 2,400 MET-min·wk-1 (Chaput, et al., 2020). According to our results, the average energy expenditure of participants in our study was higher than minimal recommended level. The discrepancy between the results on energy expenditure from IPAQ-SF and the number of steps per week measured by the pedometer was confirmed with the correlation analysis, as we only found significant correlation between the number of steps per week and energy expenditure from walking. The cause of this discrepancy may be in the modalities of physical activity that our participants had. The IPAQ-SF questionnaire would, unlike pedometer, measure physical activity in cycling, or swimming, and would include muscle strengthening exercises. On the other hand, IPAQ-SF was also shown to overestimate PA (Fillon, et al., 2022; Rääsk, et al., 2017), which is why we have to be very cautious when interpreting the results from it. The significant but weak correlation between the energy expenditure during walking and the number of steps per week assessed using pedometers may be due to differences in types of measurements. Pedometers assess

Table 5. Median values for IPAQ-SF and correlation between IPAQ-SF and pedometer

Variable	IPAQ-SF	Spearman correlation IPAQ-SF – pedometer (steps/week)	p*
Vigorous activity (MET-min·wk^{-1})	160	0.02	.906
Moderate activity (MET-min·wk^{-1})	0	0.12	.355
Walking (MET-min·wk^{-1})	1386	0.25[a]	**.045**
Sitting (MET-min·wk^{-1})	3360	-0.30	.810
Total activity (excluding sitting) (MET-min·wk^{-1})	2742	0.11	.378

Note. **p* values; [a]*p*<.05; IPAQ-SF – International Physical Activity Questionnaire–Short Form.

all steps, without limitation on minimal duration of activity, while we only included PA that lasted longer than ten minutes in the IPAQ-SF measurements.

The EFA showed two factors with high loadings and explained almost two-thirds of the total variance. The factors did not completely correspond to the scales in the instrument; the questions regarding walking (the number of days walking and an average number of minutes per day of walking) grouped in the separate factor, while the questions regarding VPA and MPA grouped in one factor. The questions regarding VPA and MPA always refer to the leisure time physical activity, while the questions for walking in the IPAQ-SF questionnaire do not differentiate between walking as an active form of commuting and as a form of leisure time physical activity, which may explain why the items referring to walking formed a separate factor. The CFA for the two-factor model showed an acceptable fit; however, the CFA for the traditional three-factor model showed even better fit.

In our study, the IPAQ-SF showed poor test-retest reliability for walking, while for other parameters it showed moderate reliability (Koo & Li, 2016). Nonetheless, the instrument showed good construct validity and, although some previous studies have showed that it can overestimate PA, it can be used as a reliable measure of PA among adolescents.

Implications for adolescent health

Assessing PA levels using the IPAQ-SF can have important implications for adolescent health. It can help schools to identify adolescents who are not meeting recommended levels of PA, to plan interventions, monitor progress, evaluate physical education programmes, and promote physical activity among adolescents:

- Adolescence is a critical period for establishing healthy behaviors, and regular PA is an important component of a healthy lifestyle. The IPAQ-SF can help identify students who are not meeting recommended levels of PA. Using the IPAQ-SF we can collect information that can be used to target interventions to increase PA levels among adolescents.
- The data collected from the IPAQ-SF can be used to plan interventions to increase PA levels among adolescents. For example, schools can use this information to develop PA programmes that are tailored to the needs of their students.
- Schools can use the IPAQ-SF to monitor the progress of their PA interventions. This can help them identify which interventions are most effective and make adjustments as needed.
- Schools can evaluate the effectiveness of their physical education programmes. This can help them identify areas where they can improve their programmes to better meet the needs of their students.
- The data collected from the IPAQ-SF can be used to promote PA among adolescents, creating awareness campaigns about the benefits of PA.

Limitations

The main limitation of our study is the modality of objective measurement, as it could not be used to assess the total PA of our participants. Another limitation is that we included only students who had iPhone, as it was the only possibility for the objective examination of physical activity. We opted for iPhone use, instead of other smartphone applications for steps measurement in order to provide the uniformity of measures. IPAQ-SF assesses only the PA that lasts longer than ten minutes, while the pedometers measure all steps, without restrictions on duration. Nonetheless, this is the first study to examine the validity and reliability of the Serbian version of IPAQ-SF in the population of adolescents and to examine its correlation with the objectively measured PA.

Our study showed that the IPAQ-SF has acceptable reliability in the population of adolescents and that it has a good validity. The PA measured by IPAQ-SF was slightly higher compared to the PA measured by pedometer, but pedometers do not assess number of different PA types. On the other hand, the overestimation of PA when using subjective measures was previously shown and although it requires caution in the interpretation of the results, has numerous advantages, especially in the population studies.

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Submitted: April 9, 2024
Accepted: August 26, 2024
Published Online First: December 17, 2024

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