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Original Article

Validity against health-related fitness and reliability of physical activity questionnaire in young female and male adults

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Abstract
Purpose: As the beneficial role of physical activity (PA) for health and well-being has been recognized recently, the need for valid and reliable assessment methods of PA has been evolved, too. Aim of this study was to examine the validity and reliability of a PA questionnaire in active young female and male adults.
Methods: Twenty four female and 30 male young adults, all undergraduate students of Physical Education and Physiotherapy performed a battery of health-related physical fitness (body composition, cardiorespiratory power, muscular strength and flexibility estimated by bioelectrical impedance analysis, maximal aerobic test, handgrip and sit-and-reach test accordingly) and responded twice to a 13-item PA questionnaire. The validation's procedure of the instrument under examination employed health-related fitness parameters as criteria. The reliability of the questionnaire was examined by test-retest procedure with an interval of two to three weeks.
Results: Body fat was highly correlated with total weekly time spent in PA in females (r=-0.73, P<0.05) and moderately in males (r=-0.46, P<0.05). Weekly total PA was highly and significantly correlated with maximal oxygen uptake for both genders (r=0.63, P<0.05 in females and r=0.57, P<0.05 in males). Strength and flexibility were low and non-significantly associated with PA. Test-retest procedure of the questionnaire revealed acceptable levels of the intraclass correlation coefficient to support its reliability.
Conclusions: Therefore, the reciprocal relationship between health-related fitness (cardiovascular fitness and body composition) and PA, as well as the reliability of the employed questionnaire were corroborated. Moreover, an instrument about the weekly time of PA, even if it did not quantify energy expenditure, could provide valuable information about the PA profile, and thus it was recommended for further use.
Key words: surveys, construction, test-retest, maximal oxygen uptake, body fat.

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Introduction

As the beneficial role of physical activity (PA) for health has been recognized recently[1], the need for valid and reliable assessment methods of PA has been evolved, too. Many methods have been proposed for the assessment of physical activity levels (pedometer, accelerometer, heart rate monitor, self-report measures). Questionnaire among them offers an inexpensive tool able to be employed in large populations and to acquire valuable data. Thus, the construction of valid and reliable physical activity questionnaire (PAQ) is a main concern of Sport science.
Generally, the validation of PAQ depends on research goal, cost and number of participants, and consists by a comparison of PAQ outcome with another already validated and reliable PA measure or indicator. Such an indicator can be the health-related physical fitness (HRF), based on the reciprocal relationship between PA and

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HRF[2-8]. HRF refers to those physical fitness components that influence health (cardiorespiratory power, body composition, flexibility, muscle strength and endurance), which distinguish from those parameters being related to skill (speed, agility, balance, coordination and reaction time)[9]. A method to examine reliability of PAQ is a test-retest procedure, i.e. participants respond twice to this PAQ and the repeatability of their answers can indicate whether this instrument provides similar outcome.

There is plethora of evidence for valid and reliable PAQ's items on children[10-13], adolescents[14-18] and older adults[19-21], while there is less research in young adults 20-30 years old. Therefore, purpose of the present study was to examine the validity and reliability of a 13-item PAQ (**Table 1**) in young females and males.

Table 1. The items of the questionnaire.

Q1) Do you practice any sport?
Q2) If your answer to the Q1 is yes, write which sport you practice. If your answer is no, go to the Q9.
Q3) How many days per week you practice this sport?
Q4) Which is the average time per session you devote in practicing this sport?
Q5) Do you practice another sport?
Q6) If your answer to the Q5 is yes, write this sport. If your answer is no, go to the Q9.
Q7) How many days per week you practice this sport?
Q8) Which is the average time per session you devote in practicing this sport?
Q9) How many days per week you practice any kind of non-sport leisure-time physical activity?
Q10) Which is the average time you devote in practicing this physical activity?
Q11) How many days per week you usually make housework?
Q12) Which is the average time per day you devote in making housework?
Q13) Which is the average time you spend usually walking per day?

Sport PA = Q3 • Q4 + Q7 • Q8
LTPA = Q9 • Q10
OPA = Q11 • Q12 + 7 • Q13
Total PA = Sport PA + LTPA + OPA

PA denotes physical activity; LTPA leisure-time PA; OPA occupational PA.

Considering the difficulties of estimating energy expenditure from PAQ or other PA measures, objective of this PAQ was to quantify weekly duration of various PA domains rather than to calculate the energetic equivalent of specific activities. Two null hypotheses were examined; first that there was no association between weekly time of exercise and health-related fitness parameters (validity) and second that there was no agreement between test-retest of the questionnaire with an interval of two to three weeks (reliability). Nevertheless, aim of the study was not only to reject the null hypotheses and adopt their alternative, but also achieve proper levels of affinity of the above parameters in order to ground validity and reliability in the light of suggested, from previous researches[19,22,23], minimal values. Particularly, acceptable level of intraclass correlation coefficient was higher than 0.61[19,22]. At least moderate ($0.30<r<0.50$) correlates with the criterion measures led to the validation of an instrument[23].

Methods

Participants and procedures. Twenty four female and 30 male undergraduate students of Physical Education and Physiotherapy volunteered as participants (**Table 2**).

Table 2. Basic data of female (N=24) and male (N=30) participants' anthropometry.

	metric unit	Females		Males	
		mean	*s*	mean	*s*
Age	years	22.72	3.19	23.81	3.89
Body mass	kg	63.98	10.45	75.36*	8.11
Height	m	1.69	0.06	1.81*	0.07
BMI	$kg \cdot m^{-2}$	22.40	2.86	23.15	2.43

s was standard deviation, BMI body mass index; * significance difference for t-test, $P<0.05$.

Participants were accustomed to a variety of physical exercise and practiced recreational activities, as basketball, tennis, jogging, swimming, and volleyball. Procedures were explained and oral informed consent was obtained prior to experimentation. All participants made one visit to the laboratory for testing on November of 2006. The measurements were realized in similar time of day, between 9 am and 12 pm, and under stable environmental conditions (temperature, humidity and barometric pressure). Skilled testers measured the components of HRF in the following order: body composition, flexibility, strength and cardiorespiratory power.

When the participants accomplished the fitness battery, they were provided with a 13-item PAQ. Based on the applied PA model, total PA was partitioned into two main components; on the one side, occupational and domestic, and on the other side, leisure-time PA (LTPA). Hereafter domestic was embodied in occupational PA, which referred to time spent on daily commuting and household chores. Sport PA, theoretically encompassed by LTPA, was studied separately from the rest LTPA. Therefore, four physical activity-related traits were examined; total PA, sport PA, LTPA and OPA (**Figure 1**).

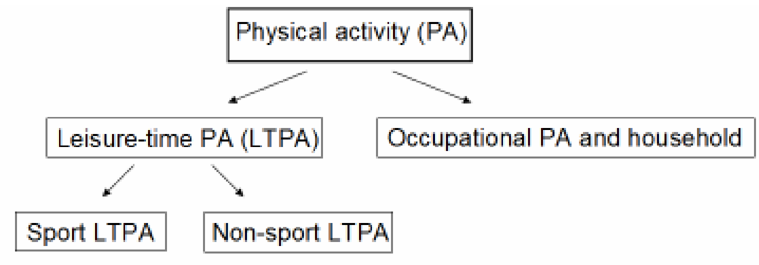

Figure 1. Employed model of physical activity.

Participants were asked to complete the questionnaire again after two-to-three weeks.

Equipment and protocols. A wall-mounted stadiometer was used to measure participants' height to the nearest centimetre. A calibrated balance-beam scale was employed to measure weight to the nearest 0.1 kg. Both measurements took place without shoes and in light clothing. Bioimpedance analysis (BIA) InBody 3.0 was employed for body composition assessment. This method was used recently to track obese students[24]. The flexibility of participants' lower back and hamstring was evaluated by the sit-and-reach test in a proper "table" providing an overhang of 15 cm. Handgrip strength was assessed by a handgrip dynamometer (Takei, Japan).

VO_{2max} test performed on a friction-loaded ergometer (Monark 824 E, Sweden), which was calibrated in a wide range of loads and revolutions. Two-gas analyzer (Servomex, 1440), one for oxygen (O_2) and one for carbon dioxide (CO_2) evaluated the exchange of gases during the cycle ergometer protocol from the exhaled air through a flowmeter (Flow transducer K 520, KL Engineering Co.). In the cycle ergometer toe clips and straps were used to avoid losing the pedals during cycling. Seat height was adjusted for each subject to allow a slight bend in the knee. Handlebars were adjusted according to individual preference. The warm up before the test included stretching exercises. Minimal warming up and learning was necessary in order to perform true maximal sprint. In the VO_{2max} test, the participants were cheered vigorously in order to reach their maximal oxygen uptake. Participants were instructed to keep an optimal pace around 90 revolutions per minute, which could be varied according to individual perception of effort and force-velocity characteristics.

The graded exercise test of VO_{2max} included two parts; during the first one, participant cycled for 4 min with resistance 1 $W \cdot kg^{-1}$ and for the following 4 min with 1.5 $W \cdot kg^{-1}$, using an optimal pedaling frequency of 80-90 rpm. In the case of individuals that practice sport related to cycling, the following workload was 2 $W \cdot kg^{-1}$ instead of 1.5 $W \cdot kg^{-1}$. The last minute's ventilation and oxygen consumption of both the above consecutive stages were recorded. The second part consisted by incremental resistance (20 W) every minute until exhaustion. In the fifth minute after the maximal oxygen uptake test's termination, blood lactate's level was evaluated through the extraction of 20 ml of capillary blood from participant's fingertip. One ml of buffer solution was added to this sample, which was further processed via a biosensor analyzer (Super GL, BioVendor). Blood lactate's level (>9 $mmol \cdot L^{-1}$), heart rate, respiratory exchange ratio ($VCO_2/VO_2>1.1$) and volitional fatigue were used as criteria for VO_{2max} achievement[25].

Data and statistical analysis. Computer statistical software NCSS 2007 and Microsoft Excel XP were employed for the statistical analysis of the data. Student t-test was employed to examine gender differences in anthropometric and physiological parameters. Pearson moment correlation coefficient *r* was used to examine the association between HRF and PA parameters and therefore to ground the validity of the PAQ. Intraclass correlation coefficient (ICC) was employed to examine the reliability of PAQ's outcome. Significance level was set at alpha=0.05

Results

HRF battery and PA scores. Initially participants' basic anthropometric data (age, body mass, stature and body mass index) were scrutinized for potential gender differences. Female and male students had different body mass and stature mean values with the latter being heavier ($t_{52}=4.51$, $P<0.05$) and taller ($t_{52}=6.79$, $P<0.05$). No gender difference was revealed for age ($t_{52}=1.11$, *n.s.*) and body mass index ($t_{52}=1.05$, *n.s.*). With respect to their PA scores, female and male participants had almost identical mean and median values for most of the traits. A discrepancy was annotated considering sport PA, where although both gender had similar mean, standard deviation and 25th-75th percentile, females had median zero, whereas males 3.5 hours per week (**Table 3**).

Table 3. Physical activity levels of participants.

	Females		Males	
	mean	*s*	mean	*s*
Total PA	17.1	6	17.4	7
	(17.3, 13-20.6)		(16.5, 10.8-23.1)	
Sport PA	3.5	5	4.3	5.4
	(0, 0-6.4)		(3.5, 0-6)	
LTPA	3.6	1.9	3	2.1
	(3, 2.8-4.5)		(3, 1-4.9)	
OPA	10.1	2.8	10	4.5
	(10.3, 8.4-11.9)		(9, 7-12.5)	

All values were presented as hours per week; median and 25th-75th percentile values were in brackets; *s* was standard deviation. A comparison of health-related fitness parameters of female and male participants revealed significant gender differences in body fat, VO_{2max} and handgrip strength (**Table 4**).

Table 4. Health-related fitness of participants.

	metric unit	Females		Males	
		mean	*s*	mean	*s*
BF	%	22.91	5.28	11.01*	4.59
VO_{2max}	$mL \cdot min^{-1} \cdot kg^{-1}$	40	6.48	54.51*	10.97
Sit-and-reach	cm	27.17	8.49	23.38	9.91
Handgrip strength	kg	31.44	5.30	51.11*	7.19

s was standard deviation, BF body fat, VO_{2max} maximal oxygen uptake; * significance difference for t-test, $P<0.05$.

Particularly females had higher percentage of body fat (t_{51}=-8.78, $P<0.05$), while males revealed higher maximal oxygen uptake (t_{52}=5.73, $P<0.05$), and handgrip strength (t_{48} =10.74, $P<0.05$). The student t test did not indicate any gender differences with respect to flexibility (t_{51}=-1.48, *n.s.*).

Body fat and PA. Body fat (%) was highly correlated with total weekly time spent in physical activity in females (r=-0.73, $P<0.05$) and moderately in males (r=-0.46, $P<0.05$; **Figure 2**).

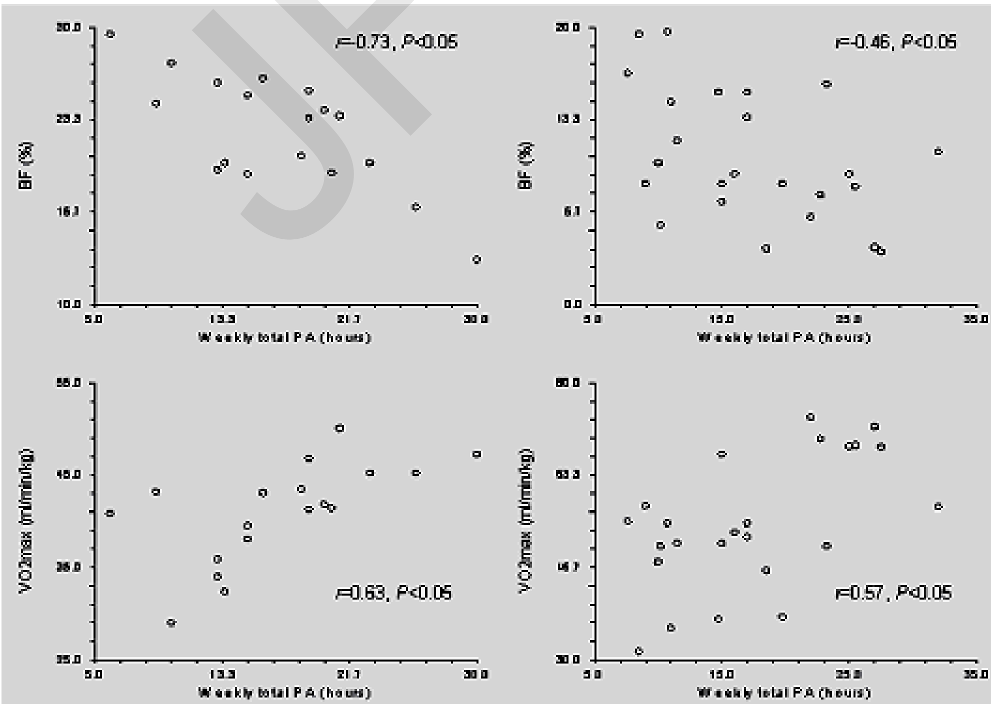

Figure 2. Association between body fat (BF) and total weekly physical activity (PA; upper row), and between maximal oxygen uptake (VO_{2max}) and total PA in females (left) and males (right; lower row).

Similar patterns, accompanied by lower association in females with respect to the previous trait, were highlighted for sport PA (r=-0.55, P<0.05 in female and r=-0.43, P<0.05 in male participants). Both genders presented very weak and non significant relationship between body fat and LTPA (r=0.06, *n.s.* and r=-0. 10, *n.s.*, accordingly). In the case of OPA, a discrepancy was underlined between the modes for female and male participants; while the former had high and significant association (r=-0.53, P<0.05), in the latter it was low and non significant (r=-0.16, *n.s.*). To sum up the above findings, the inverse relationship between PA and body fat was identified for two PA-related traits, that was, weekly total and sport PA, for both genders. Leisure- time PA had low and non significant link with body fat for genders, whilst OPA was related to body fat only in female participants.

VO_{2max} and PA. Accordingly, VO_{2max} was highly and significantly correlated with weekly total PA for both genders (r=0.63, P<0.05 in females and r=0.57, P<0.05 in males; **Figure 2**). Both genders presented almost identical high association between VO_{2max} and hours of weekly sport PA (r=0.67, P<0.05 in both cases). However, the corresponding correlations regarding leisure-time and occupational PA were low and non significant. Particularly, the association between VO_{2max} and LTPA was r=-0.14 (*n.s.*) in females and r=0.09 (*n.s.*) in males, whereas between VO_{2max} and OPA was r=0.27 (*n.s.*) and r=0.04 (*n.s.*) accordingly. To summarize the above findings, for two PA measures (total PA and sport PA) the above physiological parameters were highly and significantly correlated, while for two other PA-related traits (LTPA and OPA), there were low and non significant correlations.

Flexibility and PA. With respect to the association between flexibility and PA, for most of the PA measures, these two parameters were not significantly correlated. This pattern was stressed especially in the relationship between flexibility and weekly occupational (r=0.02, *n.s.* in females and r=0.06, *n.s.* in males) and leisure-time PA (r=0.25, *n.s.* and r=0.19, n.s. accordingly) for both genders. However, regarding these trends in total and sport PA, there were discrepancies in the results. Particularly, the link between these traits and flexibility was significant and moderate in male participants (r=0.39, P<0.05 in total PA and r=0.39, P<0.05 in sport PA), whereas it was weak and non significant in females (r=0.28, *n.s.* in total PA and r=0.18, P<0.05 in sport PA).

Muscle strength and PA. The fourth health-related fitness parameter that was examined with respect to PA was muscle strength, measured with handgrip muscle strength test. There was no statistically significant association between strength and the examined PA traits; correlation coefficient was r=0.19, r=0.10, r=0.02 and r=0.24 between total PA, sport PA, LTPA and OPA, and muscle strength in females correspondingly, while the respective values in males were r=0.06, r=-0.11, r=0.05 and r=0.20. However, even in the case that an association was classified as non significant, this per se did not prove the existence of no relationship, but probably the limitations of the applied research and statistical methods.

Reliability of questionnaire. The test-retest reliability of the PAQ was examined by the intraclass correlation coefficient (*ICC*). This index was employed separately in female and male participants and was applied in total PA and in its subcategories (sport, leisure-time and occupational PA). In females, intraclass correlation coefficient was *ICC*=0.74 for total PA, 0.83 for sport PA, 0.81 for LTPA and 0.63 for OPA. Corresponding values in males were 0.78, 0.92, 0.79 and 0.59.

Discussion

Prior to discussing the association between PA and HRF emanating from the findings of PAQ and the fitness battery, it should be annotated that this relationship was rather reciprocal than causal. In this study, the association of four HRF parameters (cardiorespiratory power, body composition, muscular strength and flexibility) with four PA traits (total PA, sport PA, LTPA and OPA) was examined.

Body composition examined by the measure of percentage of body fat was linked to total weekly time spent in PA (r=-0.73, P<0.05 in females and r=-0.46, P<0.05 in males). This finding came to terms with a study, where body fat was estimated with doubly labelled water technique and this association was r=-0.64 (P<0.05)[26], and with a research on females 20-60 y, where body fat assessed by hydrostatic weighting was associated with sport and active living habits (-0.59<r<-0.30, P<0.05)[7]. That was, the more active the participants the lower the percentage of their body fat. The underlying biological mechanism due to Gutin and Barbeau[27] was that PA could increase fat free mass, which was main determinant of resting metabolic rate and exercise might influence accumulation of fat by improving the use of lipids as a substrate for energy. The above association between PA and body fat was confirmed even for older adults (45-70 years)[6], both in males (r=-0.13, P<0.05) and in females (r=-0.17, P<0.05)[28]. However, the weakening of the association between PA and body composition with aging indicated that in older ages the employment of body composition as validity criterion of PA was not appropriate.

Between PA and cardiorespiratory power, a directly proportional relationship was delineated, as total weekly PA was highly and significantly correlated with VO_{2max} for both genders (r=0.63, P<0.05 in females and r=0.57, P<0.05 in males). This result was in accordance with previous studies[7,24,26,29], which converged as to the point that the higher the PA measure the higher the VO_{2max}. In 20-60 y females, sport and active living habits were associated with VO_{2max} (0.34<r<0.76, P<0.01)[7], while in 20-60 years old males, the group with superior (higher than 300 kcal per day) energy expenditure in PA had higher VO_{2max} with respect to the inferior one (48.04 ± 8.33

$mL \cdot kg^{-1} \cdot min^{-1}$ vs. 40.14 ± 17.33 $mL \cdot kg^{-1} \cdot min^{-1}$ accordingly) and the correlation between total energy expenditure in PA and VO_{2max} was r=0.51 (P<0.05)[30]. In older adults, the aforementioned relationship was verified (r=0.42, P<0.05, in females and r=0.31, P<0.05, in males), too[28]. In another study, HRF parameters of women were significant predictors of the time spent doing moderate to vigorous activities[31].
Test-retest procedures regarding the reliability of the questionnaire revealed high intraclass correlation coefficients (ICC). ICC was chosen as measure of reliability, because it was a measure of agreement, in contrast with Pearson and Spearman correlation coefficients that were measures of association. However, there was variation of ICC depending on the physical activity measure, the higher the intensity of PA subcategory the higher the ICC, which was resulted from the ability of participants to recall more accurate activities of higher intensity (e.g. sport participation) than activities of lower intensity (e.g. household chores). There was no gender difference with respect to this pattern. In a previous study on females, ICC was 0.90 for total PA, 0.90 for vigorous PA and 0.77 for moderate PA[32]. Therefore, our PAQ was a reliable assessment tool of PA, especially regarding moderate-to-vigorous PA.
Considering the findings of the present study in the light of the aforementioned researches on the relationship between PA and cardiorespiratory power, as well as that between PA and percentage of body fat, an attenuation of these associations with aging was indicated. This discrepancy could be partially attributed to genetic influences on both PA[33] and HRF that attenuated with aging, while environmental influences increased. The significant association between PA and HRF explained partially the variability in body composition (53.3% in females and 21.2% in males) and cardiorespiratory fitness (40% and 32.5% accordingly). On the other hand, a large part of the variability in fitness scores could not be accounted for by PA levels and sources of variability should include genetic and environmental influences (e.g. nutrition and lifestyle habits)[34].
It was purposeful to annotate in this point the effect of the participants' number on the possibility to identify significant relationships. Particularly, in order a correlation to be statistically significant, it should have value higher than 0.35 in females (given N=24) and 0.30 in males (N=30). From the existing literature, it was expected strong association between the various forms of physical activity and cardiovascular capacity, as well as between the former and body composition and therefore the qualified number of participants was adequate to identify such relationship.

Conclusions
This study examined the validity and reliability of a PAQ in young females and males. Our findings came to terms with existing knowledge and previous researches about the reciprocal relationship between PA and HRF, as well as about the employment of HRF parameters, especially cardiorespiratory power and body composition, for PAQ's validation and test-retest procedure for reliability. Moreover, an instrument about the weekly time of PA, even if it did not quantify energy expenditure, could provide valuable information about the PA profile, and thus it was recommended for further use.

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