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Research Article

Mini - Physical Activity Questionnaire (MiniPAQ): Development and Validation in Healthy Adults

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Abstract

Background and Aims: The use of feasible and low-cost methods for the assessment of physical activity is essential both in daily practice and research. Therefore, the aim of this study was to develop a very short and easy-to-use physical activity questionnaire in general population and examine its validity and reliability compared to the physical activity assessed by pedometer.

Methods: 324 adults (18-77 years of age) participated in the development and validation of the developed MiniPAQ. The validation and the reliability of the MiniPAQ compared to pedometer were examined with Bland-Altman analysis and Intraclass Correlation Coefficient (ICC). In addition, 50 adults participated in a test retest study in order to assess MiniPAQ's reproducibility.

Results: The sedentary activities were negatively correlated with calculated PAL from either the MiniPAQ or the pedometer ($p<0.05$). The Bland-Altman analysis of the developed MiniPAQ showed a not statistical significant PAL bias of -0.007 ($p=0.212$) and limits of agreement of ±0.22966; the ICC was 0.771 and the Spearman's Correlation of the test retest procedure showed an excellent reproducibility ($r^2=0.996$, $p<0.001$).

Conclusions: The developed MiniPAQ is a very short and valid with very high reproducibility physical assessment questionnaire. This makes it an ideal tool for estimating physical activity level in daily clinical practice and research, when a reference method is not applicable.

Keywords: Physical activity assessment; Physical activity questionnaire; Sedentarism assessment

Introduction

The beneficial effects of physical activity in health promotion have been documented by numerous studies, including low cardiovascular and cancer risk, improved glycaemic control, bone health, obesity management, quality of life, and decrease of overall mortality [1]. On the other hand, physical inactivity is a global burden with significant impact on public health, both in terms of human health preservation and health economics [2,3].

The physical activity and exercise prescription must be personalized and in line with individual needs and skills. To manage so, it is of great importance to assess accurately habitual physical activity or Activity Energy Expenditure (AEE), which incorporates both voluntary and non-voluntary activity. AEE can be calculated by the subtraction of the Total Energy Expenditure (TEE) minus the sum of Resting Metabolic Rate (RMR) and Thermogenetic Effect of Food (TEF). Reference methods to estimate TEE, such as Doubly Labeled Water (DLW) and direct or indirect calorimetry [4], are not always feasible either in epidemiological studies or in daily practice due to the demanding protocol. On the other hand, less complex methods and instruments such as heart rate monitors, accelerometers and step-counters are commonly used in order to assess physical activity. Indeed, many studies have been using the latter devices for the validation of simpler methods to evaluate physical activity such as questionnaires and 24hour physical activity recalls.

An alternative way to determine physical activity is via the use of physical activity questionnaires (PAQs). PAQs are considered to be appropriate for large epidemiological studies due to their low-cost and convenience. An important advantage of PAQs, in most cases, is its design, which facilitates the incorporation of the type, intensity and frequency of working, athletic and leisure activities, in order to reach to a final evaluation of physical activity. Nevertheless, PAQ's often lack precision and present a significant measurement error. The main sources of error regard to misreporting - mostly over-reporting - due to recall bias, comprehensive frailties, and often due to social bias for reporting higher physical activity than the real one.

A main issue, when assessing physical activity with PAQs, is the absence of a universal scoring system. In fact, there are various ways to quantify physical activity, as it has been reviewed before [5]. Therefore, a great number of PAQs assesses and quantifies physical activity in terms of Metabolic Equivalents of Task (METs) or minutes/hours of various intensities (e.g. light, moderate, vigorous) of physical activity per week. METs reflect the metabolic rate of an individual during a certain physical activity, according to his body mass and the condition that the resting metabolic energy expenditure is equivalent to 3.5ml of oxygen uptake per kilogram per minute [6]. On the other hand, a well-established and comprehensive measure of physical activity is the Physical Activity Level (PAL) index developed by the 1981 FAO/WHO/UNU expert consultation [7]. PAL describes the energy cost of physical performance, additionally to the Basic

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Metabolic Rate (BMR), is expressed as a numerical value, and its classification reflect an individual's habitual physical activity. To our knowledge, there is not a PAQ assessing physical activity in general population in terms of PAL. Therefore, the aim of the study was to develop a very short and easy-to-use PAQ for general population and examine its validity and reliability compared to the physical activity assessed by pedometer.

Materials and Methods

MiniPAQ development

The mini-Physical Activity Questionnaire (MiniPAQ) is divided into 4 sections according to the categories of metabolic equivalents (MET). The utility of the metabolic equivalents is found in the description of the intensity of various activities and the following estimate of the energy expenditure and their values vary depending on the intensity of the activity performed. Each questionnaire's sector examines the frequency (times per week) and the time spent (in minutes) for four different intensities of activity. The 1st sector describes low intensity activities in work (i.e. office work), house (i.e. housekeeping activities such as dishwashing, cooking, cleaning etc) and leisure activities (i.e. checkers and/or chess playing, fishing, yoga etc.). Similarly, the 2nd, 3rd and 4th sectors describe work, house and leisure/sports activities in moderate, high and very high intensity, respectively. Except for the activities assessment, the sedentarism is also assessed. In particular, two questions regarding the minutes spent watching television and/or movies and the time spent in videogames, personal computer, mobile and tablet during weekdays and weekends, in order to evaluate sedentary behaviors (Table 1).

Participants

Seven hundred eleven volunteers attended our lab. From those 324 had full data for seven consecutive days and were wearing the pedometer all day long. Therefore, the sample size of the validation cohort was 324 adults (209 women and 115 men), aged 18 to 77 years old (mean of 40.9 years and SD ±15.1 years), with a BMI range from 16.9 to 42.3 kg/m^2 (mean of 25.7 kg/m^2 and SD ±4.593 kg/m^2). Furthermore, a test-retest cohort was used of 50 white adults (age: 34.9 ±13.7 years; BMI: 23.5 kg/m^2 ±3.0 kg/m^2). The test-retest procedure was conducted by providing the MiniPAQ two times in a two-week interval. Volunteers from the wider area of the city center of Athens were asked to attend our lab. None of the participants had any disease or needed clinical care. All volunteers were informed about the procedures and the aims of the study and signed a written consent form. The study was approved by the Ethical Committee of Harokopio University and was conducted in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

Anthropometric measurements

The participants' body weight was measured with a digital scale (Seca Alpha, model 770; Seca, Hamburg, Germany) to the nearest ±100g. In order to achieve a valid body weight measurement, the individuals were measured without shoes and with light clothing. The body height was measured in an upright position with a commercial height scale (Leicester Height Measure; Invicta Plastics Ltd, Oadbly, Leics, UK) to the nearest ±0,1cm, without wearing shoes and socks and with their head oriented in a horizontal plane (Frankfort horizontal plane). Also, the heels were joined, the knees were straight and the shoulders were in a relaxed position with the arms hanging freely from them and the head, buttocks and shoulders were in contact with the height meter. From the above anthropometric measurements the Body Mass Index (kg/m^2) of the volunteers was calculated by dividing their weight (kg) by the square of their height (m^2).

Objective physical activity measurement

The actual assessment of physical activity was performed via the utilization of pedometer Omron HJ-720IT, a light and easy-to-use tool that monitors the distance, number of steps, calories and fat consumed during walking. It can record steps when placed horizontally, vertically or even upside down, a feature that makes it quite practical. It has the ability to simultaneously display on the screen, the time and the number of steps and can store in its memory data the last seven days, while it can store data that is accessible for up to 41 days. In order to estimate pace length, researchers asked the participants to perform eight consecutive normal steps on a scaled area in our lab. This variable was inserted in the pedometer's setting for each individual. In this context, the pedometer provides information regarding total distance travelled. Furthermore, the researchers asked the participants to wear the pedometer for seven consecutive days during every daily habitual physical or sedentary activity or exercise, except for activities involving contact with water (e.g. swimming, bathing) and the hours during nighttime or daytime sleep.

Physical activity level calculations

The PAL was determined from the data derived from the pedometer, according to IOM report [8]. The recorded traveled distance (km) from each examinee was converted into PAL taking into account their body weight. The PAL of the MiniPAQ resulted from the use of a special algorithm created from data of the MiniPAQ. In particular, for each type of physical activity, a median value of metabolic equivalent was obtained qualitatively and multiplied by the frequency (times/week) and the time (minutes/times) that each physical activity lasted. For the calculation of sedentary activities, the time spent on other types of activities was subtracted from the total minutes of the week and multiplied by the median value of the metabolic equivalent corresponding to sedentary activities. Then, all the types of physical activities were summed up and divided by the minutes of the week, thus calculating the level of physical activity of each person. The special questionnaire algorithm is described as follows:

$$PAL\ (MiniPAQ) = [1.4 * Fa_1 * Da_1 + 2.8 * Fa_2 * Da_2 + 2.2 * Fa_3 * Da_3 + 2.8 * Fb_1 * Db_1 + 3.5 * Fb_2 * Db_2 + 4.8 * Fb_3 * Db_3 + 6.2 * Fc_1 * Dc_1 + 7.6 * Fc_2 * Dc_2 + 10.1 * Fd_1 * Dd_1 + [(10080 - Fa_1 * Da_1 - Fa_2 * Da_2 - Fa_3 * Da_3 - Fb_1 * Db_1 - Fb_2 * Db_2 - Fb_3 * Db_3 - Fc_1 * Dc_1 - Fc_2 * Dc_2 - Fd_1 * Dd_1) * 1.2]]/10080$$

Where, F: frequency (times/week), D: Duration (minutes/times), a_1: Low intensity work activities, a_2: Low intensity household activities, a_3: Low intensity recreational activities, b_1: Moderate intensity work activities, b_2: Moderate intensity household activities, b_3: Moderate intensity recreational or sports activities, c_1: High intensity work activities, c_2: High intensity recreational or sports activities, d_1: Very high intensity sports activities, 1.4: median value of PAL index for

Table 1: Mini Physical Activity Questionnaire (MiniPAQ).

Activity's Intensity	Type of Activity	Times/ week	Minutes/ time
Low intensity			
Professional activities	Sedentary office work		
Household activities	Dishwashing, wiping, mopping, cooking, etc.		
Recreational activities	playing cards, chess, backgammon, painting, yoga, golf, fishing etc		
Moderate Intensity			
Professional activities	Building cleaning, moving objects, working on the street, playing musical instruments, scratching - scrubbing floors, working with a hammer, construction work, etc.		
Household activities	Moving objects, gardening, home repairs, etc.		
Recreational - Sports activities	Fencing, resistance training, volleyball, skating, windsurfing, rackets, low-intensity aerobics, dancing, table tennis, walking, etc.		
High Intensity			
Professional activities	Very heavy construction work and manual work		
Household activities	**No applicable**		
Recreational - Sports activities	Basketball, football, tennis, running, swimming, martial arts, polo, mountain biking, diving, mountaineering, intense aerobic exercise		
Very High Intensity			
Professional activities	**No applicable**		
Household activities	**No applicable**		
Sports activities	Competitive participation in the activities of the previous category		
Sedentary activities			
		Daily	Weekend
Minutes	Television, DVD		
Minutes	Videogames, computer, mobile, tablet,		

low intensity work activities, 2.8: median value of PAL index for low intensity household activities, 2.2: median value of PAL index for low intensity recreational activities, 2.8: median value of PAL index for moderate intensity work activities, 3.5: median value of PAL index for moderate intensity household activities, 4.8: median value of PAL index for moderate intensity recreational or sports activities, 6.2: median value of PAL index for high intensity work activities, 7.6: median value of PAL index for high intensity recreational or sports activities, 10.1: median value of PAL index for very high intensity sports activities, 10080: the number of minutes per week, 1.2: median value of PAL index for sedentarism.

Statistical analysis

Normality of continues variables was evaluated through the Kolmogorov-Smirnow test. Continuous variables are presented as mean±standard deviation. Bland-Altman analysis, Pearson Correlation, and Intraclass Correlation Coefficient (ICC) were used so as to validate the estimated physical activity level from the MiniPAQ compared to the measured. Any differences between the two physical activity level estimations, bias, and its statistical significance were checked with t-test paired samples. A test-retest procedure was performed with Spearman Correlation. The statistical significance was set on P <0.05. All statistical calculations were performed using the SPSS 21.0 version, software (SPSS Inc, Chicago, IL).

Results

The basic characteristics of the study's population are presented in Table 2 and 3. The variables "Total Daily Steps" and "PAL (pedometer)" and "PAL (questionnaire)" resulted from the analysis

Table 2: Basic characteristics of the participants (N=324).

Variable	Mean	Standard deviation
Age (years)	40.9	15.1
BMI (kg/m^2)	25.7	4.5
Total Daily Steps	6033	3000
PAL (pedometer)	1.5	0.11
PAL (MiniPAQ)	1.49	0.13
Tv, DVD hours (weekdays)	102.5	98.5
Tv, DVD hours (weekend)	110.7	99.2
Videogames, pc, mobile, tablet hours (weekdays)	124.3	146
Videogames, pc, mobile, tablet hours (weekend)	110.4	126

BMI: Body Mass Index; PAL: Physical Activity Level.

of the pedometer software and the questionnaire, respectively. Furthermore, the weekdays and weekend time spent watching television or DVD movies were negatively correlated both with PALMiniPAQ (r= -0.137 and r= -0.131, p<0.05 respectively) and PALpedometer (r= -0.103 and r= -0.145, p<0.05 respectively).

The validation of the MiniPAQ's physical activity level compared to pedometer's physical activity level is presented in Table 3. The developed MiniPAQ's physical activity level showed a not statistical significant PAL bias of -0.007 (p=0.212). Furthermore, it was found to be valid with high ICC (0.771) and the correlation coefficient showed an adequate statistical significant linear relationship.

Finally, in the test retest procedure the MiniPAQ was found to have an excellent reproducibility of Spearman Correlation (r^2= 0.996,

Table 3: Validation of the developed Mini Physical Activity Questionnaire (MiniPAQ) (N=324).

	BIAS	Sig. (2 tailed)	Limits of agreement	ICC	r	pr
MiniPAQ	-0.007	0.212	0.22966	0.771	0.407	<0.001

ICC: Intraclass Correlation Coefficient; r: Pearson correlation of MiniPAQ's and pedometer's physical activity level; pr: significance of r.

Table 4: Basic characteristics of the participants and correlation coefficient for the test-retest study (N=50).

Variable	Mean	Standard deviation		
Age (years)	34.9	13.7		
BMI (kg/m^2)	23.5	3	r	p_r
$MiniPAQ_{bl}$	1.766	0.592	0.998	<0.001
$MiniPAQ_{fu}$	1.768	0.599		

$MiniPAQ_{bl}$: MiniPAQ's physical activity level at baseline; $MiniPAQ_{fu}$: MiniPAQ's physical activity level at follow up after 2 weeks; r: Pearson correlation of PAQ's physical activity level at baseline and follow up; pr: significance of r.

p<0.001) as presented in Table 4.

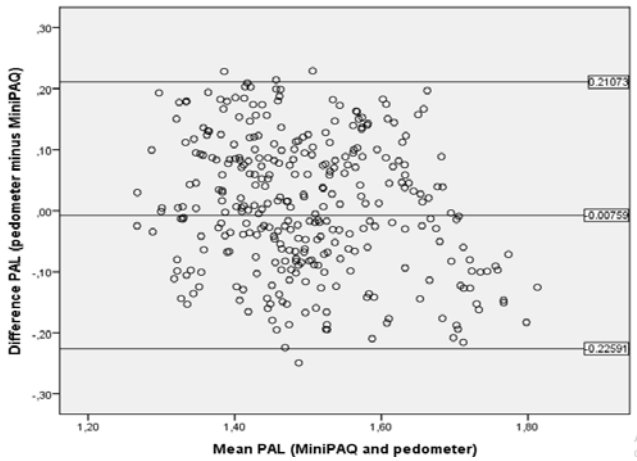

Figure 1: Bland Altman plot for the developed MiniPAQ's and the pedometer's physical activity level.

Discussion

The critical issue when assessing physical activity via specialized questionnaires, both in research and daily practice, is the interpretation and convention of the collected data to measures or values that can be easily exploited by the health professional. Therefore, the aim of the present study was to develop a physical activity questionnaire (MiniPAQ), that it could be assessed via a less complex and widely acknowledged index of physical activity such as PAL [9].

The validity of the developed MiniPAQ was examined with the Bland Altman Test technique. Regarding correlation coefficients, the correlation between the MiniPAQ-PAL and the PAL as measured by the pedometers, was considered to be acceptable (r= 0.407). Furthermore, the ICC test highlighted a significant Cronbach's alpha of 0.771. Finally, the Bland Altman Test technique resulted in a non-significant bias (Table 3, Figure 1). In addition, in order to assess the reproducibility of the questionnaire, a test-retest survey was conducted. The results of the test-retest study showed a very strong statistical significant correlation for the developed MiniPAQ between the baseline and the follow-up periods (r= 0.998, p<0.001).

The main innovative characteristic of the developed self-reported MiniPAQ is the conversion of the documented physical activity information to a more layman index, the PAL. In addition, the significant validity and repeatability of the questionnaire was due to the relevant large population sample of the study and its short and easy-to-answer design. In comparison to similar studies, the sample of 324 volunteers for the validation cohort is considered to be among the largest samples [10]. Furthermore, the structure of the developed MiniPAQ enhances the identification of a broad range of physical activity, ranking an examinee from sedentarism to active lifestyle. Except for the importance of a valid recording of physical activity, it is also necessary to detect accurately the sedentarism in a person's lifestyle. In general, there is a lack of questionnaires assessing sedentarism in non-clinical populations [11]. The developed MiniPAQ contains also questions regarding lifestyle parameters, such as watching television and spending leisure time on videogames etc. that can be assessed separately both in clinical practice and research.

The validity of the current questionnaire is comparable with the majority of similar questionnaires. For example, the physical activity questionnaire developed by Manocci et al (2010) revealed similar Cronbach's alpha (0.730) [12]. Furthermore, a former questionnaire developed in a similar ethnical population achieved larger validity than the current study (ICC: 0.95), but of significant smaller population size (N=60) and applicable only for younger adults (mean age: 20y) [13]. On the other hand, questionnaires developed in older adults had similar correlations with accelerometers (r: 0.11 to 0.44) to this of the current study, but no other validity and reproducibility measures were applied [14]. In general, correlation coefficient does not seem to have a great potential when comparing self-reported questionnaires with accelerometers, since ranges from 0.20 to 0.46 [15]. The main drawback resulting in differences between actual and self-reported physical activity level is the over-reporting bias. Particularly, this bias tends to increase in line with the increase of physical activity's intensity.

The current study has some limitations. First of all, no reference method was used for the assessment of physical activity level. In addition, the use of pedometers, that have assessed physical activity level, cannot produce measurements for activities taking place in water, i.e. swimming. Additionally, pedometers cannot distinguish between exercises of different intensity. Finally, none of the participants of the two cohorts had very high physical activity level, since the MiniPAQ study had not used data from athletes. Therefore, the developed MiniPAQ is not applicable for individuals have PAL higher than 2.0.

In conclusion, the developed MiniPAQ is a very short and valid with very high reproducibility physical assessment questionnaire. This makes it an ideal tool for estimating physical activity level in daily clinical practice and research, when a reference method is not applicable. Further validation of the MiniPAQ with the use of accelerometers would enhance its accuracy.

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Statement of Authorship

The authors' contributions are as follows: YM contributed to the study design; SK was the principal investigator and contributed to the study design and interpretation of the findings and statistical analyses and data collection and co-wrote the manuscript; ES contributed to the study design and interpretation of the findings and statistical analyses and data collection and co-wrote the manuscript; MS, EB, AT, and MS contributed to data collection. All authors read and approved the final version of the manuscript.

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