European Journal of Sport Science
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t714592354

International Physical Activity Questionnaire: Reliability and validity in a Spanish population

Blanca Roman-Viñas[a]; Lluis Serra-Majem[b]; Maria Hagströmer[c]; Lourdes Ribas-Barba[a]; Michael Sjöström[c]; Ramon Segura-Cardona[d]
[a] Community Nutrition Research Centre, University of Barcelona Science Park, Barcelona, Spain [b] Department of Clinical Sciences, University of Las Palmas de Gran Canaria, Spain [c] Prevnut at Novum, Karolinska Institute, Stockholm, Sweden [d] Physiological Sciences II, Medical School, University of Barcelona, Barcelona, Spain

Online publication date: 17 August 2010

To cite this Article Roman-Viñas, Blanca , Serra-Majem, Lluis , Hagströmer, Maria , Ribas-Barba, Lourdes , Sjöström, Michael and Segura-Cardona, Ramon(2010) 'International Physical Activity Questionnaire: Reliability and validity in a Spanish population', European Journal of Sport Science, 10: 5, 297 — 304
To link to this Article: DOI: 10.1080/17461390903426667
URL: http://dx.doi.org/10.1080/17461390903426667

European Journal of Sport Science, September 2010; 10(5): 297–304

Routledge
Taylor & Francis Group

ORIGINAL ARTICLE

International Physical Activity Questionnaire: Reliability and validity in a Spanish population

BLANCA ROMAN-VIÑAS[1], LLUIS SERRA-MAJEM[2], MARIA HAGSTRÖMER[3], LOURDES RIBAS-BARBA[1], MICHAEL SJÖSTRÖM[3], & RAMON SEGURA-CARDONA[4]

[1]*Community Nutrition Research Centre, University of Barcelona Science Park, Barcelona, Spain,* [2]*Department of Clinical Sciences, University of Las Palmas de Gran Canaria, Spain,* [3]*Prevnut at Novum, Karolinska Institute, Stockholm, Sweden and* [4]*Physiological Sciences II, Medical School, University of Barcelona, Barcelona, Spain*

Abstract

Although questionnaires are useful for evaluating patterns of physical activity in populations, they need to be validated. The objective of this study was to determine the validity and reliability of the long version of the International Physical Activity Questionnaire (IPAQ) in a Spanish population. The participants wore a uniaxial MTI Actigraph (Computer Science and Application, Inc.) accelerometer for 7 days and self-completed the IPAQ questionnaire twice, to assess its reliability. Criterion validity was assessed by comparing data from the IPAQ and data from the MTI. The final sample included 54 adults for the validity analysis and 66 adults for the reliability analysis. The correlations (r) between the IPAQ and the accelerometer were 0.29 ($P<0.05$) for total physical activity (MET $\cdot$ min^{-1} $\cdot$ day^{-1}) versus total counts per minute, 0.30 ($P<0.05$) for time spent in vigorous activity, and 0.34 ($P<0.05$) for time spent sitting. The IPAQ showed a good reliability coefficient for total physical activity ($r=0.82$, $P<0.05$), vigorous activity ($r=0.79$, $P<0.05$), moderate activity ($r=0.83$, $P<0.05$), and time spent walking ($r=0.73$, $P<0.05$). Total time spent on work-related physical activities ($r=0.92$, $P<0.05$), on household-related activities ($r=0.86$, $P<0.05$), and leisure-time physical activities (excluding walking) ($r=0.82$, $P<0.05$) showed good reliability coefficients. Bland Altman analysis showed that discrepancies between the two methods increased with the amount of moderate and vigorous physical activity undertaken. In conclusion, the long version of the IPAQ has acceptable validity for the measurement of total and vigorous physical activity, and good reliability coefficients for application in the Spanish population studied here. The questionnaire showed poor validity for reporting moderate-intensity activity in this Spanish population.

Keywords: *Physical activity, validation, questionnaire, assessment*

Introduction

The measurement of physical activity has become a priority in health-related sciences due to its relationship with many chronic diseases (Mokdad, Marks, Stroup, & Gerberding, 2000) and all-cause mortality (Manini et al., 2006; Oguma, Sesso, Paffenbarger, & Lee, 2002). Subjective methods of measuring physical activity are useful with large populations (Livingstone, Robson, Wallace, & McKinley, 2003; Montoye, Kemper, Saris, & Washburn, 1996) as they are inexpensive and easy to apply. Although subjective have their limitations (Westerterp, 1999), they are useful when the goal is to monitor changes in physical activity patterns in a population (Shephard, 2003). Since the 1970s, more than 50 different types of physical activity questionnaires have been developed and some of them have undergone validation (Dishman, Washburn, & Heath, 2004; Lagerros & Lagiou, 2007; Sallis & Saelens, 2000; Shephard, 2003). As the current recommendations on physical activity for health-enhancing purposes refer to all kinds of physical activity, it was necessary to develop questionnaires that took into account not only physical activity related to work, but also the physical activity undertaken during leisure time and for transportation. The International Physical Activity Questionnaire (IPAQ) was developed to evaluate physical

Correspondence: B. Roman-Viñas, Community Nutrition Research Centre, University of Barcelona Science Park, c/ Baldini Reixac 4, 08028 Barcelona, Spain. E-mail: dietmed@pcb.ub.es

ISSN 1746-1391 print/ISSN 1536-7290 online
DOI: 10.1080/17461390903426667

activity at work, for getting around, during leisure time, and for household tasks. It has been validated in many countries with different correlation coefficients (Craig et al., 2003; Ekelund et al., 2006; Hagströmer, Oja, & Sjöström, 2006) but it has not been validated in a Spanish population. The purpose of the present study, therefore, was to assess the validity and reproducibility of the self-administered, long format of the IPAQ in a Spanish population.

Methods

Sample

A convenience sample was recruited by word-of-mouth among acquaintances of participating researchers. Seventy-five residents of Barcelona (42 females, 33 males) aged 20–68 years volunteered to participate. After being informed of the aims of the study, the participants provided informed consent. Individuals completed a questionnaire on socioeconomic factors, including type of work, highest educational standard achieved, and number of inhabitants of place of residence (less than 1000, 1000–29,900, 30,000–100,000, and more than 100,000 inhabitants). Self-reported weight and height were also registered.

Self-reported physical activity questionnaire

In this study, we used the last 7 days self-administered long form of the IPAQ. The questionnaire was translated into Spanish and back-translated into English following the recommendations of the IPAQ committee (www.ipaq.ki.se). The questionnaire evaluates physical activity at work, for transportation, during leisure time, and at home. The frequency of (per week) and time spent on vigorous- and moderate-intensity activities and the time spent walking are registered for each category, together with the time spent sitting during a work day and on a weekend day. Explanations and practical examples for vigorous and moderate physical activities are given. To be registered, an activity must last at least 10 min.

Accelerometer

Criterion validity was evaluated with a uni-axial accelerometer, the MTI Actigraph (formerly known as the CSA Actigraph), a small and lightweight (45 g) device. It had previously been validated in adult populations for quantifying the intensity of physical activity (Brage, Wedderkopp, Franks, Andersen, & Froberg, 2003; Computer Science and Applications, Inc., 1995; Plasqui & Westerterp, 2007). Data output is reported as activity counts. The cut-off points used in this study were as follows: vigorous intensity, more than 5724 counts per minute; moderate intensity, 1952–5724 counts per minute; and low intensity, 101–1951 counts per minute (Freedson, Melanson, & Sirard, 1998). Sedentary activities were defined by a cut-off point of less than 101 counts per minute (Yngve, Nilsson, Sjöström, & Ekelund, 2003). The MTI data were downloaded to a personal computer for analysis and reinitialized again using the reader interface unit supplied by the manufacturer. After downloading the information, only those individuals with at least 5 days of at least 600 min of registered time per day were included in further analysis (Craig et al., 2003). Total time (per minute) spent in each intensity of activity according to the proposed cut-off points and total activity (expressed as total counts per minute) were registered.

Procedure

Individuals wore the accelerometer attached to their waist for 7 consecutive days. The device was not to be removed except when going to sleep or when bathing or going swimming. An agenda was designed to register the time the accelerometer was put on and the time it was taken off.

On the eighth day of the evaluation period, the questionnaire was self-completed. The accelerometer and the questionnaire were then returned. To conduct the reliability study, the questionnaire was again completed on day 10. The participants were instructed that the questions should be answered according to the activity they had undergone during the period they had worn the accelerometer.

Data management

The IPAQ data were introduced twice to guarantee the quality of the data input. For data analysis, moderate intensity was defined as 4 METs (metabolic equivalent task) and vigorous intensity as more than 8 METs (Craig et al., 2003). Walking activity was defined as 3.3 METs. One MET is the energy expended at rest and is defined as 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$.

The following outcomes were calculated from the results of the questionnaire:

1. Total energy expenditure (METs $\cdot$ min^{-1} $\cdot$ day^{-1}) defined as the product of the times spent at each intensity of activity based on the specific counts for that activity (Craig et al., 2003).

2. Minutes per day reported in vigorous and moderate physical activity and the minutes per day spent walking and sitting.
3. For each domain, the sum of the total minutes per day spent in each intensity of activity, excluding the time spent sitting.

Values are presented as means and standard deviations, minimum and maximum values. A *t*-test was used to compare anthropometry, total physical activity, and time spent on each activity based on intensity (according to the MTI data) between males and females. The normality of the frequency distributions of the variables of the questionnaire and the MTI were evaluated by the Kolmogorov-Smirnov statistical test. All the variables included in the validation analysis except time spent on vigorous activities were normally distributed. For the reliability analysis, only time spent sitting was normally distributed. Outliers were defined as those individuals scoring three standard deviations above the mean. As their exclusion did not modify the results, they were not eliminated from the analysis.

Criterion validity

The information obtained from the MTI (total counts per minute, time registered in moderate and vigorous intensity, and time spent on sedentary activities) was compared with the information gathered with the IPAQ: total energy expenditure (total METs per day, METs $\cdot$ min^{-1} $\cdot$ day^{-1}), time spent on vigorous activities, time spent on moderate activities, and time spent sitting, respectively. Criterion validity for time spent on moderate activities was calculated twice, once for the MTI data against IPAQ data on moderate activities, and then moderate activities plus time spent walking. For the MTI data, participants' average values were calculated using the number of days of recorded values.

Reliability

The main outcomes for measuring reliability were total energy expenditure (METs $\cdot$ min^{-1} $\cdot$ day^{-1}), time spent on vigorous and moderate activities, walking and sitting (min^{-1} $\cdot$ day^{-1}), and the time spent on leisure activities, transport, on household activities, and during leisure time, excluding sitting. A physical activity score was calculated as the percentage of individuals who met the 1995 Centers for Disease and Control (CDC) and American College of Sports Medicine (ACSM) guidelines (US Department of Health and Human Services, 1996) for physical activity: accumulating a minimum of 30 min of at least moderate-intensity exercise at least five times per week or 20 consecutive minutes of vigorous activity at least three times per week. This score was calculated as twice the time spent on vigorous activities plus the time spent on moderate activities plus the walking time recorded with the IPAQ (Armstrong, Bauman, & Davies, 2000; Hallal, Victora, Wells, & Lima, 2003). As the CDC/ACSM recommendations refer to leisure-time physical activities, only the reported minutes of leisure time were included.

Statistical analysis

The relationship between physical activity variables from the IPAQ and the accelerometer and test–retest reliability were analysed using correlation coefficients (Spearman's correlation coefficient if the variable was non-normally distributed, and Pearson's correlation coefficient for the variables with a normal distribution).

Criterion validity was also assessed using the Bland-Altman method by plotting the differences between the two methods against their averages, and the 95% limits of agreement were used to describe the total error between the two methods. The variables used for this analysis were time spent on moderate- and vigorous-intensity activities. Statistical significance was set at $P<0.05$.

Reproducibility was also assessed as the percentage of agreement between the classifications of individuals according to the 1995 CDC/ACSM recommendations for improving health. The kappa statistic was used to measure agreement between categorical variables. Kappa values above 0.75 represented good agreement, between 0.40 and 0.75 moderate agreement, and values below 0.40 poor agreement.

The Statistical Package for the Social Sciences (SPSS, version 12.0) for Windows was used to perform all statistical analyses.

Results

After data cleaning, the final sample included 54 individuals (31 females, 23 males) for the validity analysis and 66 individuals (39 females, 27 males) for the reliability analysis. Individuals who did not wear the accelerometer ($n=3$), who had missing values on the questionnaires ($n=8$) or who had insufficient registered counts ($n=10$) were excluded from the validity analysis. Average daily accelerometer counts were derived from 7 days of registered data for 29 participants, 6 days of registered data for 13 participants, and 5 days of registered data for 12 participants. Individuals with incomplete questionnaires were excluded from the reliability analysis. The characteristics of the sample for the validity analysis are presented in Table I.

Table I. Descriptive characteristics of the sample ($n=54$)

Males (%)	42.6
Females (%)	57.4
Age (years)	$43.2 \pm 14.1^{\#}$
Height (m)	$1.66 \pm 8.8^{\#}$
Weight (kg)	$67.9 \pm 14.2^{\#}$
Body mass index ($kg \cdot m^{-2}$)	$24.4 \pm 3.4^{\#}$
Work status (%)	
unemployed	8.0
employed	92.0
Population of residence (%)	
<29,900	7.4
30,000–100,000	3.7
>100,000	83.3
Education (%)	
no higher education	72.5
higher education	27.5

[#]Values are means ± standard deviations.

The mean age of the participants was 42 years. There were no statistical differences between males and females for time spent on vigorous or moderate physical activities, for time spent walking or sitting according to the MTI data. Men had higher body mass index (BMI) than females (26.3 vs. 22.9) ($P<0.01$). Five individuals were classified as obese (BMI ≥ 30 $kg \cdot m^{-2}$). Eighteen percent of the sample had basic education – that is, they had completed compulsory education (education up to the age of 14 years) – and 28% had completed their university studies. Eight percent of the sample was unemployed and 83% of participants lived in the city of Barcelona.

Criterion validity

Table II shows raw data for the minutes of activity from the IPAQ and the MTI. The total reported mean duration of activity for the IPAQ was 711 min · day^{-1}, with 22 min · day^{-1} of vigorous activities, 167 min daily of moderate intensity activities, 149 min · $week^{-1}$ walking and 373 min sitting. The MTI registered a mean total of 888 min, 1 min of vigorous activity, 41 min of moderate activity, and 482 min of sedentary activity.

Table III shows correlation coefficients between the accelerometer measures and data derived form the IPAQ long format. There was a moderate Pearson's correlation coefficient for total physical activity ($r=0.29$, $P<0.05$), moderate Spearman's correlation coefficient for time spent on vigorous physical activity ($r=0.30$, $P<0.05$), and moderate Pearson's correlation coefficient for time spent sitting ($r=0.34$, $P<0.05$) between the MTI and the IPAQ data. There was no significant correlation between the reported time spent on moderate-intensity activity and the MTI data (moderate intensity). The sum of the time dedicated to moderate-intensity activity plus walking reported by the IPAQ was also evaluated against the MTI moderate-intensity activity recorded time. No correlation was observed.

Figures 1 and 2 show the Bland-Altman plots for time spent on vigorous and moderate physical activities. The solid line in the plot reflects the mean of the difference between the accelerometer and the questionnaire (-20 min · day^{-1} for vigorous physical activity and -126 min · day^{-1} for moderate physical activity), and the dashed lines show the 95% confidence interval around the mean of the differences: being larger for moderate activity (from -479.5 to 226.9 min · day^{-1}) than for vigorous physical activity (from -119 to 78 min · day^{-1}). The number of outliers outside the 95% confidence interval increased with the number of minutes measured by the accelerometer. The difference among the time dedicated to moderate and vigorous activities self-reported by the IPAQ and registered by the accelerometer increased with the amount of activity. Test–retest reliability data are shown in Table IV.

Results showed a good Spearman's correlation coefficient for total physical activity ($r=0.82$), minutes spent in vigorous physical activities ($r=0.79$), minutes spent in moderate physical activities ($r=0.83$), and time spent walking ($r=0.73$), and

Table II. Raw data comparing the participants' average IPAQ activity with the accelerometer (MTI) scores per day ($n=54$)

	IPAQ (min · day^{-1})				MTI (min · day^{-1})			
	Mean	*s*	Minimum	Maximum	Mean	*s*	Minimum	Maximum
Vigorous	21.8	49.7	0.0	214.3	1.3	2.7	0.0	12.0
Moderate	167.0	178.5	0.0	780.0	40.6	27.8	0.0	126.4
Walking	149.4	136.0	0.0	548.6	—	—	—	—
Sitting IPAQ/ Sedentary MTI	373.1	184.3	85.7	803.6	481.9	121.1	276.5	850.2
Total activity time	711.4	239.5	286.4	1495.7	888.1	69.8	744.2	1019.6

Note: Cut-off points for MTI data: vigorous activity, >5724 counts per minute; moderate activity, 1952–5724 counts per minute; sedentary activity, <101 counts per minute. IPAQ, International Physical Activity Questionnaire; MTI, accelerometer.

Table III. Pearson's correlations for the time spent in different intensities of physical activity and total activity according to data obtained with the IPAQ and MTI ($n=54$)

MTI counts per minute vs. total physical activity (METs · min^{-1} · day^{-1})	$r=0.29^a$
MTI minutes vigorous vs. IPAQ minutes vigorous (min · day^{-1})[#]	$r=0.30^a$
MTI minutes moderate vs. IPAQ minutes moderate (min · day^{-1})	$r=0.15$
MTI minutes moderate vs. IPAQ minutes moderate +walking (min · day^{-1})	$r=0.10$
MTI minutes sedentary vs. IPAQ minutes sitting (min · day^{-1})	$r=0.34^a$

[#]Spearman's correlation coefficient. IPAQ, International Physical Activity Questionnaire; MTI, accelerometer.
[a]$P<0.05$.

a moderate Pearson's correlation coefficient for time spent sitting ($r=0.40$). Time spent in physical activity at work and at home showed a good Spearman's correlation. There was a moderate Spearman's correlation for time spent on different activities during leisure time ($r=0.51$), but the correlation improved when time spent walking was excluded from the total of the time spent on physical activities during leisure time ($r=0.82$). The percentage of individuals who were sufficiently active was 68%. The kappa coefficient for the agreement between the information obtained with the two methods was 0.61, in compliance with the 1995 CDC-ACSM guidelines.

Discussion

The correlation ($r=0.29$) for the IPAQ in the present Spanish population is lower than in other countries where the IPAQ has previously been

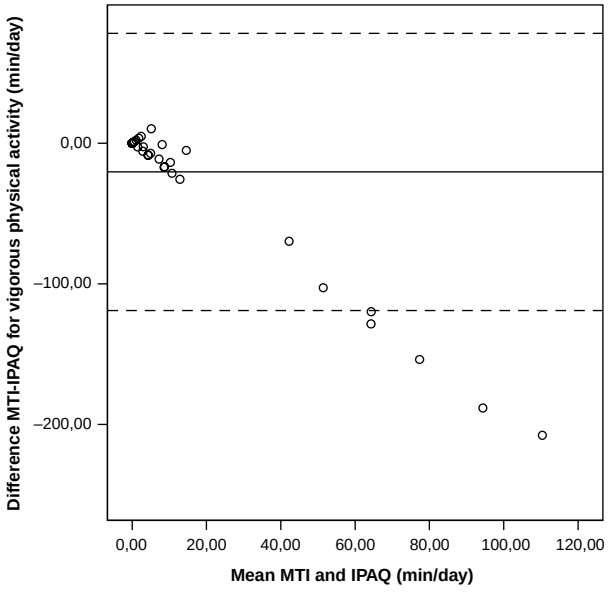

Figure 1. Bland-Altman plot for time spent in vigorous physical activity (min · day^{-1}) according to MTI data and IPAQ data.

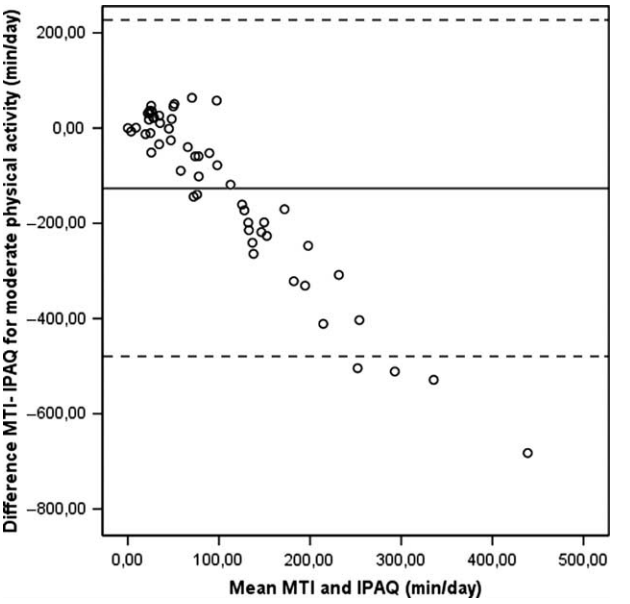

Figure 2. Bland-Altman plot for time spent in moderate physical activity (min · day^{-1}) according to MTI data and IPAQ data.

validated (Ekelund et al., 2006; Hagströmer et al., 2006) but similar to other validation studies conducted in Spain (De Abajo, Larriba, & Marquez, 2001; Elosua, Marrugat, Molina, Pons, & Pujol, 1994; Elousa et al., 2000; Lopez-Fontana, Martinez-Gonzalez, Sánchez-Villegas, & Martinez, 2005; Martinez-Gonzalez, Lopez-Fontana, Varo, Sánchez-Villegas, & Martinez, 2005). There are several possible reasons for the results, the first of which is the low levels of physical activity in the Spanish population. According to comparative international studies, the Spanish population is one of the most inactive in Europe (Hallal et al., 2003; Rzewnicki, Vanden Auweele, & De Bourdeauhuij, 2003). In our study, the analysis of the

Table IV. Test–retest reliability (Spearman's correlation coefficient) for total physical activity and time spent in different intensities of physical activity according to data obtained with the IPAQ completed on two occasions (3–4 days apart)

Total physical activity (METs · min^{-1} · day^{-1})	$r=0.82^a$
Minutes vigorous physical activity	$r=0.79^a$
Minutes moderate physical activity	$r=0.83^a$
Minutes walking	$r=0.73^a$
Minutes sitting[#]	$r=0.40^a$
Minutes vigorous, moderate and walking to work-related physical activities	$r=0.92^a$
Minutes vigorous and moderate household physical activities	$r=0.86^a$
Minutes vigorous and moderate leisure-time activities (including walking)	$r=0.51^a$
Minutes vigorous and moderate leisure-time activities (excluding walking)	$r=0.82^a$

[#]Pearson's correlation coefficient. IPAQ, International Physical Activity Questionnaire; MTI, accelerometer.
[a]$P<0.01$.

responses to the IPAQ showed that the sample had poor physical activity habits. Some individuals reported not walking at all, or at least not for bouts of 10 min duration. It has been speculated that individuals with low physical activity patterns tend to overestimate their responses in a physical activity questionnaire (Ekelund et al., 2006; Rutten et al., 2003; Sallis & Saelens, 2000). This factor may also explain the differences between the mean time spent on different intensities of physical activity according to the questionnaire and the accelerometer. As the Bland-Altman analysis for moderate- and vigorous-intensity activity showed, the discrepancies between the questionnaire and the accelerometer increased with increasing levels of reported activity on the questionnaire. Improving the ability of the questionnaire to capture moderate-intensity physical activities would enhance its validity, especially in a sample with low levels of physical activity and with a high proportion of women.

Second, although accelerometers have been defined as one of the best objective methods to validate a questionnaire (Pols, Peeters, Kemper, Grobbee, 1998) and ensure independence of errors with self-reported measurements, they have some limitations. For example, we used the cut-off points proposed by Freedson et al. (1998), which were defined under laboratory conditions and in a population that may have had different physical activity patterns than the present Spanish one. Other authors have also suggested the possibility of specific cut-off points for different populations (Macfarlane, Lee, Ho, Chan, & Chan, 2007). Also, uniaxial accelerometers are known to underestimate activities of moderate intensity (Welk, Blair, Wood, Jones, & Thompson, 2000). In our study, females represented 57% of the sample, and 23% of the sample were unemployed or underemployed (housekeepers or baby sitters), activities that may involve movements that the accelerometer is unable to evaluate with accuracy. Moreover, accelerometers are limited in their ability to register aquatic activities and cycling. It is likely that individuals who used to swim regularly included the time spent swimming as a moderate-intensity activity not recorded by the MTI. For bicycling, the mean time reported by the IPAQ was low, being less than 1 min per day, and thus we did not take this activity into account.

The IPAQ relies on the ability of the individual to recall past physical activities. Addressing a large list of activities such as those reported in the IPAQ may lead to over-reporting. In addition, the perception of the intensity of the exercise that has been undertaken depends on the individual's previous experiences (Shephard, 2003). Although the questionnaire defines what moderate and vigorous intensity are, each individual will apply these definitions according to their fitness level, age, sex, and so on. We examined the effect that some variables, including age, gender, educational level, amount of leisure-time physical activity, and being overweight or of normal weight, may have had on the correlation coefficients for moderate-intensity activites. Correlations did not improve according to the variables analysed, except for age group. When we stratified individuals according to age (less than 30 years, 30–50 years, and older than 50 years), the correlation for the time spent in moderate-intensity activities improved and became significant in the youngest cohort. Nevertheless, this result must be interpreted with caution due to the low number of individuals ($n = 12$) in this age group. Although not significant, the correlations for moderate activities were higher among men than women.

That the IPAQ may over-report physical activity has been noted before (Chasan-Taber et al., 2002; Johnson-Kozlow, Sallis, Gilpin, Rock, & Pierce, 2006). Chasan-Taber et al. (2002) found that using the short format of the IPAQ, 40% of individuals over-reported vigorous and moderate physical activity and over two-thirds of the sample over-reported walking (Chasan-Taber et al., 2002). Based on such results, some researchers recommend using the long version of the IPAQ instead of the short one to overcome the likelihood of such over-reporting (US Department of Health and Human Services, 1996). Nevertheless, considering our results, it is also questionable whether the long format could overcome such over-reporting. In any case, the literature suggests that those activities that are structured, of high intensity, and are performed regularly are easier to recall than those that are irregular and of lower intensity (Johnson-Kozlow et al., 2006). Indeed, we investigated the effect that high levels of habitual physical activity in the population had on the correlation analysis. Those individuals in the highest quartile of minutes of vigorous physical activity registered by the MTI and also in the highest quartile of minutes spent on vigorous activities reported by the IPAQ, registered higher correlation coefficients for the MTI total counts per minute versus the IPAQ total energy expenditure (METs $\cdot$ $\text{min}^{-1} \cdot \text{day}^{-1}$) ($r = 0.64$, $P < 0.05$) than those in the lowest percentile ($r = 0.21$, not statistically significant). As it is likely that physical activity that is not of a vigorous intensity also benefits health, it is of utmost importance to correctly evaluate activities of lower intensity. Perhaps if an interviewer were to assist the individual to recall when, where, and how the behavior took place, this would help improve the efficacy of the IPAQ (Rzewnicki et al., 2003).

Finally, there are cultural differences that may have influenced the responses to the IPAQ. Although

the questions were culturally adapted, some, such as those referring to gardening, were maintained for the Spanish version. The study was conducted in Barcelona, a city where the percentage of the population with a house with a garden or a courtyard big enough to conduct some level of physical activity is low.

Other validity studies conducted in Spain reported similar results to ours. The Minnesota Leisure-time Physical Activity Questionnaire gave correlations of 0.02–0.51 between energy expenditure and a fitness test for Spanish females and of 0.4–0.57 for Spanish males (Elosua et al., 1994, 2000). Martinez Gonzalez et al. (2005) reported a correlation of 0.507 for leisure-time physical activity in a sample of obese women using the Nurses' Health Study Physical Activity Questionnaire.

The results for the reproducibility of the IPAQ are similar to those observed by the IPAQ committee (Craig et al., 2003). The lowest correlation reliability coefficients were seen for time spent sitting and walking. The long version of the IPAQ asks up to three times about time spent walking. Individuals may have found it difficult to divide the overall time spent walking into the different domains.

One of the limitations of the present study lies in sample recruitment. The study sample was not random or large enough, and participating individuals had higher levels of education than the Spanish population as a whole.

Our results indicate acceptable criterion validity (for total physical activity, time spent in vigorous activity, and time spent sitting) and good reproducibility (for total physical activity, vigorous and moderate activities, and time spent walking) for the long Spanish version of the IPAQ in the present Spanish population. However, the IPAQ overestimated self-reported time spent on physical activity.

Acknowledgements

The authors acknowledge Josep M[a] Ramon, University of Barcelona, for supervision of the statistical procedures and Joy Ngo, Centre of Community Nutrition Research at the Science Park of the University of Barcelona, for supervision of the English version. Special thanks to Elena Maestre, Glòria Cuadrado, and Natalia Prat, dietitians who helped the authors with the fieldwork and to all the participants, whose collaboration made this study possible.

References

Armstrong, T., Bauman, A., & Davies, J. (2000). *Physical activity patterns of Australian adults: Results of the 1999 National Physical Activity Survey.* Canberra, ACT: Australian Institute of Health and Welfare.

Brage, S., Wedderkopp, N., Franks, P. W., Andersen, L. B., & Froberg, K. (2003). Reexamination of validity and reliability of the CSA monitor in walking and running. *Medicine and Science in Sports and Exercise*, *35*, 1447–1454.

Chasan-Taber, L., Erickson, J. B., McBride, J. W., Nasca, P. C., Chasan-Taber, S., & Freedson, P. S. (2002). Reproducibility of a self-administered lifetime physical activity questionnaire among female college alumnae. *American Journal of Epidemiology*, *155*, 282–289.

Computer Science and Applications, Inc. (1995). *Activity monitor operator's manual*, Model 7164, Version AM7164-2.2. Shalimar, FL: CSA.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*, 1381–1395.

De Abajo, S., Larriba, R., & Marquez, S. (2001). Validity and reliability of the Yale Physical Activity Survey in Spanish elderly. *Journal of Sports Medicine and Physical Fitness*, *41*, 479–485.

Dishman, R. K., Washburn, R., & Heath, G. W. (2004). Measurement and surveillance of physical activity and fitness. In R. K. Dishman, R. Washburn, & G. W. Heath (Eds.), *Physical activity epidemiology* (pp. 33–67). Champaign, IL: Human Kinetics.

Ekelund, U., Sepp, H., Brage, S., Becker, W., Jakes, R., Hennings, M., et al. (2006). Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutrition*, *9*, 258–265.

Elosua, R., Garcia, M., Aguilar, A., Molina, L., Covas, M. I., & Marrugat, J. (2000). Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish women: Investigators of the MARATDON Group. *Medicine and Science in Sports and Exercise*, *32*, 1431–1437.

Elosua, R., Marrugat, J., Molina, L., Pons, S., & Pujol, E. (1994). Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish men: The MARATHOM Investigators. *American Journal of Epidemiology*, *139*, 1197–1209.

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sports and Exercise*, *30*, 777–781.

Hagströmer, M., Oja, P., & Sjöström, M. (2006). The International Physical Activity Questionnaire (IPAQ): A study of concurrent and construct validity. *Public Health Nutrition*, *9*, 755–762.

Hallal, P. C., Victora, C. G., Wells, J. C., & Lima, R. C. (2003). Physical inactivity: Prevalence and associated variables in Brazilian adults. *Medicine and Science in Sports and Exercise*, *35*, 1894–1900.

Johnson-Kozlow, M., Sallis, J. F., Gilpin, E. A., Rock, C. L., & Pierce, J. P. (2006). Comparative validation of the IPAQ and the 7-Day PAR among women diagnosed with breast cancer. *International Journal of Behavioural Nutrition and Physical Activity*, *3*, 7–11.

Lagerros, Y. T., & Lagiou, P. (2007). Assessment of physical activity and energy expenditure in epidemiological research of chronic diseases. *European Journal of Epidemiology*, *22*, 353–362.

Livingstone, M. B., Robson, P. J., Wallace, J. M., & McKinley, M. C. (2003). How active are we? Levels of routine physical activity in children and adults. *Proceedings of the Nutrition Society*, *62*, 681–701.

Lopez-Fontana, C. M., Martinez-Gonzalez, M. A., Sánchez-Villegas, A., & Martínez, J. A. (2005). Comparison between two methods to estimate physical activity in obese women: Accelerometry and self-administered questionnaire. *Archivos Latinoamericanos de Nutricion*, *55*, 257–266.

Macfarlane, D. J., Lee, C. C., Ho, E. Y., Chan, K. L., & Chan, D. T. (2007). Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *Journal of Science and Medicine in Sport*, *10*, 45–51.

Manini, T. M., Everhart, J. E., Patel, K. V., Schoeller, D. A., Colbert, L. H., Visser, M., et al. (2006). Daily activity energy expenditure and mortality among older adults. *Journal of the American Medical Association*, *296*, 71–79.

Martinez-Gonzalez, M. A., Lopez-Fontana, C., Varo, J. J., Sánchez-Villegas, A., & Martinez, J. A. (2005). Validation of the Spanish version of the Physical Activity Questionnaire used in the Nurses' Health Study and the Health Professionals' Follow-up Study. *Public Health Nutrition*, *8*, 920–927.

Mokdad, A. H., Marks, J. S., Stroup, D. F., & Gerberding, J. L. (2000). Actual causes of death in the United States, 2000. *Journal of the American Medical Association*, *291*, 1238–1245.

Montoye, H. J., Kemper, H. C. G., Saris, W. H. M., & Washburn, R. A. (1996). Questionnaires and interviews. In H. J. Montoye, H. C. G. Kemper, & W. H. M. Saris (Eds.), *Measuring physical activity and energy expenditure* (pp. 42–71). Champaign, IL: Human Kinetics.

Oguma, Y., Sesso, H. D., Paffenbarger, R. S., Jr., & Lee, I. M. (2002). Physical activity and all cause mortality in women: A review of the evidence. *British Journal of Sports Medicine*, *36*, 162–172.

Plasqui, G., & Westerterp, K. R. (2007). Physical activity assessment with accelerometers: An evaluation against doubly labeled water. *Obesity*, *15*, 2371–2379.

Pols, M. A., Peeters, P. H. M., Kemper, H. C. G., & Grobbee, D. E. (1998). Methodological aspects of physical activity assessment in epidemiological studies. *European Journal of Epidemiology*, *14*, 63–70.

Rutten, A., Ziemainz, H., Schena, F., Stahl, T., Stiggelbout, M., Auweele, Y. V., et al. (2003). Using different physical activity measurements in eight European countries: Results of the European Physical Activity Surveillance System (EUPASS) time series survey. *Public Health Nutrition*, *6*, 371–376.

Rzewnicki, R., Vanden Auweele, Y., & De Bourdeaudhuij, I. (2003). Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutrition*, *6*, 299–305.

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, *71*, S1–S14.

Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine*, *37*, 197–206.

US Department of Health and Human Services (1996). *Physical activity and health: A report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

Welk, G. J., Blair, S. N., Wood, K., Jones, S., & Thompson, R. W. (2000). A comparative evaluation of three accelerometry-based physical activity monitors. *Medicine and Science in Sports and Exercise*, *32*, S489–S497.

Westerterp, K. R. (1999). Assessment of physical activity level in relation to obesity: Current evidence and research issues. *Medicine and Science in Sports and Exercise*, *31*, S522–S525.

Yngve, A., Nilsson, A., Sjöström, M., & Ekelund, U. (2003). Effect of monitor placement and of activity setting on the MTI accelerometer output. *Medicine and Science in Sports and Exercise*, *35*, 320–326.