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Validation of the Global Physical Activity Questionnaire for self-administration in a European context

Miriam Wanner,[1,2] Christina Hartmann,[3] Giulia Pestoni,[2,4] Brian Winfried Martin,[2,5] Michael Siegrist,[3] Eva Martin-Diener[2]

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[1]Cancer Registry Zurich and Zug, University Hospital Zurich, Zurich, Switzerland
[2]Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, Switzerland
[3]Department of Health Sciences and Technology, Institute for Environmental Decisions, ETH Zurich, Zurich, Switzerland
[4]Department of Health Sciences and Technology, Institute of Human Movement Sciences, ETH Zurich, Zurich, Switzerland
[5]Department of Health, Canton Basel-Landschaft, Liestal, Switzerland

Correspondence to
Dr Miriam Wanner; miriam.wanner@uzh.ch

ABSTRACT

Background/aim Little is known about the measurement properties of the self-administered Global Physical Activity Questionnaire (GPAQ) in Europe. The aim was to validate the self-administered GPAQ against accelerometry in Switzerland in German, French and Italian.

Methods Participants of this cross-sectional study were recruited among members of the Swiss Food Panel (German-speaking and French-speaking samples) and as a convenience sample (Italian-speaking sample). They completed the GPAQ and wore an Actigraph GT3X+ accelerometer during 7 days in 2014/2015. GPAQ and accelerometer data on total physical activity and different intensities, as well as sitting time, were compared using Spearman correlations and Bland-Altman plots.

Results Complete data were available for 354 participants (50.6% women, mean age: 47.0 years) on physical activity, and for 366 on sitting time. Correlations were highest for vigorous physical activity (r=0.46) and sitting time (r=0.47). A significant sex difference was apparent for vigorous physical activity (men: r=0.35 vs women: r=0.55; p=0.02). Some age differences were present especially for total physical activity, with the lowest correlations found for those aged 60+ years. The correlation for sitting time was significantly higher in the youngest age group (r=0.61) compared with the middle (r=0.38, p=0.01) and the oldest age groups (r=0.37, p=0.03). Total physical activity was 2.8 times higher according to the GPAQ than to accelerometer data.

Conclusions The self-administered version of the GPAQ showed fair-to-moderate validity in the three languages tested, both for men and women and individuals aged ≤60 years. For older individuals, a careful interpretation of total physical activity is required.

What are the new findings?

- Validity of the self-administered Global Physical Activity Questionnaire in a European context compared with accelerometry.
- Highest correlations for vigorous physical activity (r=0.46) and sitting time (r=0.47).
- Fair-to-moderate validity in all subgroups but lower correlations for individuals aged 60 years and older.

INTRODUCTION

Questionnaires are widely used tools for the assessment of physical activity both for monitoring purposes and in scientific research projects. Advantages of physical activity questionnaires are that they can be used in large studies at relatively low costs and that information regarding various domains of physical activity is available. However, completing physical activity questionnaires can be cognitively difficult,[1] and recall bias and social desirability may also have an impact on the results.[2] Therefore, it is important to validate physical activity questionnaires in different populations. Accelerometers are the state-of-the-art method for objective assessments of physical activity and thus also the standard method to assess concurrent validity of physical activity questionnaires.[3]

The Global Physical Activity Questionnaire (GPAQ) was developed in 2002 in the frame of the WHO 'STEPwise approach for Surveillance of risk factors for chronic disease' (STEPS).[4 5] It was developed to combine the strengths of the short and the long International Physical Activity Questionnaire (IPAQ) by including different domains (work, transport and leisure time), but nevertheless being considerably shorter (16 items) than the long IPAQ (27 items). The GPAQ also assesses sitting time. According to the WHO, the GPAQ has been administered in more than 100 countries, mainly in the frame of STEPS (www.who.int/chp/steps/GPAQ/en/index.html) and in low/middle-income countries.[6]

Initially, the measurement properties of the GPAQ were assessed in nine countries mostly in Asia, Africa and South America.[4] Subsequently, the GPAQ was validated against objectively assessed physical activity

in Latinas in the USA,[7] in Vietnam,[8 9] in Malaysia[10] and in another study in the USA.[11] In the European context, the GPAQ has been compared with the IPAQ in Portugal[4] and validated against objectively assessed physical activity using accelerometers in a more recent study in Great Britain.[12] Overall, correlations were moderate. Even though only few validation studies are available in a Western context, the GPAQ is being used more and more also in European countries, for example, in Germany,[13] in the Czech Republic[14] and in Switzerland.[15 16] No validation studies exist for the German, French and Italian versions of the GPAQ.

Originally, the GPAQ was developed for face-to-face interviews administered by trained staff to cope with challenges such as reading problems. However, in European countries this questionnaire is often used in a self-administered format to save costs and time. To our knowledge there are only three validation studies comparing physical activity assessed with a self-administered format of the GPAQ with physical activity objectively assessed by accelerometers or pedometers,[7 17 18] and none of them from a European context. The latest one of these studies[18] compared physical activity assessed with both the self-administered and interviewer-administered formats of the GPAQ with objectively assessed physical activity in Singapore and found similar validity of the two formats.

The aim of the present study was thus to validate the GPAQ against accelerometry in Switzerland in German, French and Italian and in different age groups using a self-administered format which was culturally adapted to a European context.

METHODS

Study design and participants

In the German-speaking and French-speaking regions, individuals were recruited among the participants of the Swiss Food Panel, a population-based longitudinal study that has been assessing eating behaviour in Switzerland since 2010.[19] A paper-and-pencil questionnaire is used for annual data collection. In the 2014 survey, participants were asked whether they were interested in participating in a study using objective physical activity assessment. In the Italian-speaking region, a convenience sample was recruited mainly via a call in a newspaper.

Interested individuals were contacted by telephone and given detailed instructions on the study and the handling of the accelerometers. The accelerometer, the GPAQ and additional information material were sent by postal mail. Participants were instructed to complete the GPAQ prior to starting the accelerometer measurement and to return all the materials using a prepaid padded envelope. Recruitment and data collection were between August 2014 and March 2015 in all parts of Switzerland. Inclusion criteria were ≥18 years, living in Switzerland, and understanding German, French or Italian. The aim was to include about 100 participants per language region based on a rule of thumb that at least 50 subjects are considered adequate in validation studies.[20]

Table 1 The number of individuals in different phases of the recruitment procedure

Language region	German (N)	French (N)	Italian (N)
Indication of interest in participation*	571	186	191
Contact by telephone attempted	195	186	191
Accelerometer and GPAQ questionnaire sent by postal mail†	129	93	174
Valid accelerometer and questionnaire data for physical activity	119	85	150
Valid accelerometer and questionnaire data for sitting time	120	86	160

*A telephone contact was not attempted with all interested individuals in the German-speaking part due to the high number of interested individuals.
†Individuals who did not get an accelerometer and questionnaire either could not be contacted by telephone, declined participation or participation was not feasible.
GPAQ, Global Physical Activity Questionnaire.

Table 1 gives an overview of the number of individuals in different phases of the recruitment procedure. Complete data were available for 354 participants on all aspects of physical activity and for 366 participants on sitting time. The study was approved by the ethical committee of the Canton of Zurich, Switzerland, and all participants provided written informed consent.

Measures

Sex and age were assessed on the informed consent form, while language region was available based on the recruitment procedure.

Accelerometer

Accelerometers of the type Actigraph GT3X+ (Actigraph, Pensacola, Florida, USA) were used to assess objective physical activity using an epoch time of 5 s, which was reintegrated to 60 s for the analyses.[21] The normal filter option was applied.[22] The ActiLife 5 software was used to initialise and download the accelerometers. The device was attached to an elastic belt, and individuals were asked to wear it on the right hip during waking hours for seven consecutive days. For water-based activities, the accelerometer had to be taken off. Individuals were included in the analyses if valid data were available for at least 4 days,[21] including at least one weekend day.[23] A day was considered valid

if at least 10 hours of data were recorded. Participants included in the analyses had on average 6.8 valid days of accelerometer data, 82.3% had seven, 13.7% had six, 3.7% had five and 0.3% had four valid days.

Questionnaire

A self-administered format of the GPAQ was developed based on the original versions of the GPAQ in German, French and Italian (available at http://www.who.int/chp/steps/GPAQ/en). The German version was adapted to a self-administered paper-and-pencil format by rewording sentences such as 'Next I am going to ask you…' which are not appropriate in a self-administered version. Furthermore, a cultural adaptation regarding the examples given for different activities was necessary in order to reflect the European context. These adaptations were prepared in the research group at the University of Zurich and involved international experts and an expert from the WHO. The adaptations in the German version were then translated to French and Italian and integrated in the original French and Italian versions. The GPAQ questionnaires validated in this study are available in the online supplementary material document 1.

Statistical analyses

ActiLife V.6.11.2 was used to clean the accelerometer data. Non-wear time was defined as 60 or more minutes of consecutive 0s (allowing for 2 min within these 60 min with values greater than 0 but smaller than 100 counts/min). In order to classify accelerometer output data into different physical activity intensity categories, the following cut points were used: minutes per week spent in sedentary (<100 counts/min),[24] light (100–2019 counts/min), moderate (2020–5998 counts/min) and vigorous (≥5999 counts/min) physical activity.[25 26] The number of steps per day was also calculated. The mean wear time among all participants was 14.5 hours/day. In order to account for differences in wear time, we standardised the individual physical activity output variables (min/week) to a mean wear time of 14.5 hours/day.

GPAQ data were cleaned according to the GPAQ analysis guide of the WHO.[27] We calculated min/week spent in moderate and vigorous activities, as well as the sum of both intensities (moderate-to-vigorous physical activity). Furthermore, the MET-min/week (metabolic equivalent) of total and domain-specific activities was calculated. One MET is equal to the energy expended during rest (3.5 mL O_2/kg/min). Finally the number of hours/week spent sitting was derived.

STATA IC V.12 was used for analyses. GPAQ and accelerometer variables were reported as means and SD. Unpaired t-tests and analysis of variance were used to test for differences between sex, age groups and language regions. Spearman correlations were used to compare GPAQ and accelerometer data. 95% CIs based on Fisher's z transformation were calculated, and differences between subgroups according to sex, age category and language region were tested (immediate command 'cortesti' in STATA). The following criteria were used to interpret the Spearman correlation coefficients: 0–0.20=poor correlation, 0.21–0.40=fair correlation, 0.41–0.60=moderate/acceptable correlation, 0.61–0.80=substantial correlation and 0.81–1.0=near perfect correlation.[12] Bland-Altman plots were used to assess the extent of agreement between the two measures. These plots show the mean of the two measurements (x-axis) versus the difference (y-axis). Furthermore, the limits of agreement were calculated using the formula 'mean difference between the two instruments ±1.96 × SD deviation'. The level of statistical significance was set to $p<0.05$.

RESULTS

Characteristics of study population

For 354 participants, valid accelerometer and GPAQ data were available regarding physical activity. The characteristics of these participants are described in table 2. Regarding sitting time, 366 participants had valid accelerometer and GPAQ data and could be included in the analyses. The age range of the participants was 18–83 years.

Physical activity and sitting time

Table 3 shows the different physical activity and sitting time variables for GPAQ and accelerometer data stratified by sex, age group and language region. The amount of minutes per week spent in moderate-to-vigorous physical activities was 2.8 times higher according to GPAQ than to accelerometer data. There was no difference in moderate-to-vigorous physical activity between men and women regardless of the measurement instrument. Concerning sitting time, accelerometer-measured time was 1.2 times higher than sitting time reported in the GPAQ. Sitting time was significantly higher in men than in women based on both GPAQ and accelerometers. Vigorous physical activity was significantly higher in men than in women according to the GPAQ but not according to accelerometers. There was no sex difference for moderate physical activity.

Individuals aged 60 years and older reported significantly more moderate-to-vigorous physical activity in the GPAQ compared with younger age groups; however, such a difference was not reflected in the accelerometer data. Therefore, overestimation of physical activity in the GPAQ compared with accelerometer measurements was 4.2 for the oldest age group versus 2.5 in the two younger age groups. Vigorous physical activity was highest in the youngest age group. There was no significant difference in sitting time between age groups according to both accelerometer and GPAQ data.

Differences between language regions were found mainly for vigorous physical activity, with higher levels in the Italian-speaking region both according to accelerometer and GPAQ data. This is probably due to the

Table 2 Characteristics of the participants

	Total	Male	Female	p
N	354	175	179	
Sex (%)		49.4	50.6	
Mean age (years)	47.0 (15.0)	46.6 (15.5)	47.4 (14.5)	0.60
Age category (%)				
18–39 years	37.3	38.3	36.3	
40–59 years	39.5	38.3	40.8	
≥60 years	23.2	23.4	22.9	0.89
Language region (%)				
German	33.6	30.3	36.9	
French	24.0	21.1	26.8	
Italian	42.4	48.6	36.3	0.07

different age structure of the Italian sample (mean age: 39.9 years versus 51.6 years in the German-speaking and 53.2 years in the French-speaking region, p<0.001), which is based on the different recruitment strategy. There was no significant difference between language regions for sitting time irrespective of measurement instrument.

Concurrent validity

Table 4 shows the Spearman correlations between GPAQ and accelerometer data. Online supplementary material table 1 additionally includes the 95% CIs based on Fisher's z transformation. Correlations were highest for sitting time (r=0.47 for total sample, range between 0.29 and 0.61 for subgroups stratified by sex, age category and language region) and vigorous physical activity (r=0.46 for total sample, range between 0.21 and 0.55). Fair correlations were observed for leisure-time physical activity (GPAQ) versus moderate-to-vigorous physical activity (accelerometer, r=0.28 for total sample, range between 0.22 and 0.37) and for total MET-min per week (GPAQ) versus number of steps (accelerometer, r=0.25 for total sample, range between 0.02 and 0.38) or counts/min (accelerometer, r=0.22, range between 0.03 and 0.36). For moderate physical activity based on the GPAQ, correlations were higher when compared to light than to moderate activities (accelerometer).

Significant sex differences in the correlations were apparent for vigorous physical activity (men: r=0.35 vs women: r=0.55, p=0.021). Age differences were present mainly between the youngest and the oldest age groups for all total physical activity variables (MET-min/week or min/week in moderate-to-vigorous physical activity according to GPAQ, respectively, vs counts/min, steps or min/week in moderate-to-vigorous physical activity according to accelerometer, respectively). For vigorous physical activity, there was a significant difference between the middle (r=0.52) and the oldest (r=0.21) age groups (p=0.01). For sitting time, significant differences in the correlation coefficients were apparent between the youngest (r=0.61) and the middle (r=0.38) age groups (p=0.013), as well as between the youngest and the oldest (r=0.37) age groups (p=0.027). The only significant differences in correlation coefficients between language regions were present for sitting time with German (r=0.57) versus French (r=0.29, p=0.016), and French versus Italian (r=0.48, p=0.042).

Bland-Altman plots

Figure 1 shows the Bland-Altman plots for the agreement of data assessed with accelerometers and with the GPAQ. In figure1A–C (total, vigorous and moderate physical activity), the mostly negative difference between accelerometer and GPAQ data supports the fact that physical activity was overestimated in the GPAQ. The mean difference for total physical activity was -553 min/week (-9.2 hours/week, SD 16.0 hours/week). Furthermore, individuals that were more active were more likely to overreport physical activity in the GPAQ. The limits of agreement are wide, with the difference lying between −2433 and 1328 min/week for total physical activity. For sitting time (figure 1D), the mean difference was 10.3 hours/week (SD 21.9 hours/week), indicating an underreporting of this activity in the GPAQ on average compared with objective measurements. However, there were also several individuals who overreported sitting time in the GPAQ (a number of points lie below 0).

DISCUSSION

To our knowledge, this study is one of only few studies on the validity of the GPAQ in a European context

Table 3 Objective and self-reported physical activity behaviour (mean (SD)) by gender, age group and language region

		Sex			Age category				Language region			
	Total	Male	Female	p	18–39 years	40–59 years	≥60 years	p	German	French	Italian	p
Total physical activity												
GPAQ (MET-min/week)	4197.0 (4583.6)	4379.5 (4422.7)	4018.6 (4741.2)	0.46	3898.9 (4596.0)	3753.3 (3775.1)	5434.4 (5559.3)	*0.02*	4238.5 (4850.9)	3450.1 (4157.9)	4587.3 (4573.7)	0.19
GPAQ (min/week in mvpa)	852.8 (955.1)	856.8 (920.9)	848.7 (990.0)	0.94	718.6 (888.5)	779.4 (840.2)	1193.8 (1153.6)	*<0.001*	891.6 (996.8)	766.6 (944.3)	870.7 (930.5)	0.63
Accelerometer (counts/min)	396.7 (140.9)	398.8 (139.2)	394.6 (142.8)	0.78	394.6 (139.2)	414.0 (143.9)	370.5 (135.6)	0.08	389.3 (142.5)	370.9 (127.8)	417.1 (144.4)	*0.04*
Accelerometer (min/week in mvpa)	300.1 (162.8)	310.5 (154.9)	290.0 (170.0)	0.24	292.7 (149.6)	314.6 (160.9)	287.4 (185.1)	0.39	296.1 (165.4)	279.4 (153.7)	315.0 (165.3)	0.26
Vigorous activities												
GPAQ (min/week)	196.5 (312.6)	238.0 (307.7)	155.9 (312.8)	*0.01*	256.2 (356.9)	158.8 (216.3)	164.8 (360.8)	*0.02*	168.0 (295.4)	95.9 (202.8)	276.1 (355.4)	*<0.001*
Accelerometer (min/week)	35.9 (63.4)	41.5 (65.5)	30.5 (61.0)	0.10	44.4 (62.1)	41.5 (70.5)	12.8 (45.0)	*<0.001*	25.0 (58.7)	20.2 (43.7)	53.5 (71.8)	*<0.001*
Moderate activities												
GPAQ (min/week)	656.3 (840.7)	618.8 (814.2)	692.9 (866.5)	0.41	462.4 (716.6)	620.7 (784.1)	1029.1 (995.0)	*<0.001*	723.6 (831.3)	670.8 (886.1)	594.6 (822.6)	0.45
Accelerometer (min/week)	264.2 (146.1)	269.0 (135.3)	259.5 (156.1)	0.54	248.3 (126.8)	273.1 (139.5)	274.6 (181.4)	0.29	271.1 (151.3)	259.2 (138.7)	261.5 (146.8)	0.81
Sitting												
GPAQ (hours/week)	51.5 (24.5)	54.5 (25.1)	48.5 (23.6)	*0.02*	52.9 (25.8)	52.9 (23.6)	46.8 (23.4)	0.13	50.7 (23.9)	53.7 (26.1)	50.9 (24.1)	0.62
Accelerometer (hours/week)	61.8 (8.4)	63.7 (8.4)	59.8 (8.0)	*<0.001*	63.1 (8.5)	61.0 (8.4)	60.8 (8.0)	0.06	61.4 (9.5)	61.1 (7.5)	62.3 (8.1)	0.48

p-values <0.05 are presented in italics.
GPAQ, Global Physical Activity Questionnaire; MET, metabolic equivalent; mvpa, moderate-to-vigorous physical activity.

Table 4 Spearman correlations (r) for time spent in different physical activity intensities and domains as recorded by GPAQ and Actigraph accelerometers

			Sex		Age category			Language region		
GPAQ	**Accelerometer**	**Total**	**Male**	**Female**	**18–39 years**	**40–59 years**	**≥60 years**	**German**	**French**	**Italian**
Total (MET-min/week)	Total (counts/min)	0.22***	0.13	0.31***	0.36***	0.23**	0.03	0.25**	0.22*	0.16
Total (MET-min/week)	Total (steps)	0.25***	0.20**	0.31***	0.38***	0.28***	0.02	0.26**	0.29**	0.20*
Total (min/week in mvpa)	Total (min/week in mvpa)	0.11*	0.04	0.17*	0.28***	0.06	−0.0008	0.16	0.13	0.02
Vigorous (min/week)	Vigorous (min/week)	0.46***	0.35***	0.55***	0.40***	0.52***	0.21	0.34***	0.41***	0.42***
Moderate (min/week)	Moderate (min/week)	0.16**	0.16*	0.17*	0.25**	0.11	0.08	0.18*	0.17	0.11
Moderate (min/week)	Light (min/week)	0.30***	0.33***	0.24**	0.26**	0.31***	0.13	0.31***	0.22*	0.31***
Sitting (hours/week)	Sitting (hours/week)	0.47***	0.44***	0.49***	0.61***	0.38***	0.37***	0.57***	0.29**	0.48***
Physical activity at work (MET-min/week)	mvpa (min/week)	−0.13*	−0.13	−0.12	−0.01	−0.19*	−0.17	−0.08	−0.17	−0.16
Transport activities (MET-min/week)	mvpa (min/week)	0.15**	0.15*	0.15*	0.17	0.20*	0.02	0.12	0.19	0.15
Leisure-time physical activity (MET-min/week)	mvpa (min/week)	0.28***	0.24**	0.32***	0.37***	0.22**	0.26*	0.24**	0.35***	0.22**

*p≤0.05, **p≤0.01, ***p≤0.001.
GPAQ, Global Physical Activity Questionnaire; MET, metabolic equivalent; mvpa, moderate-to-vigorous physical activity.

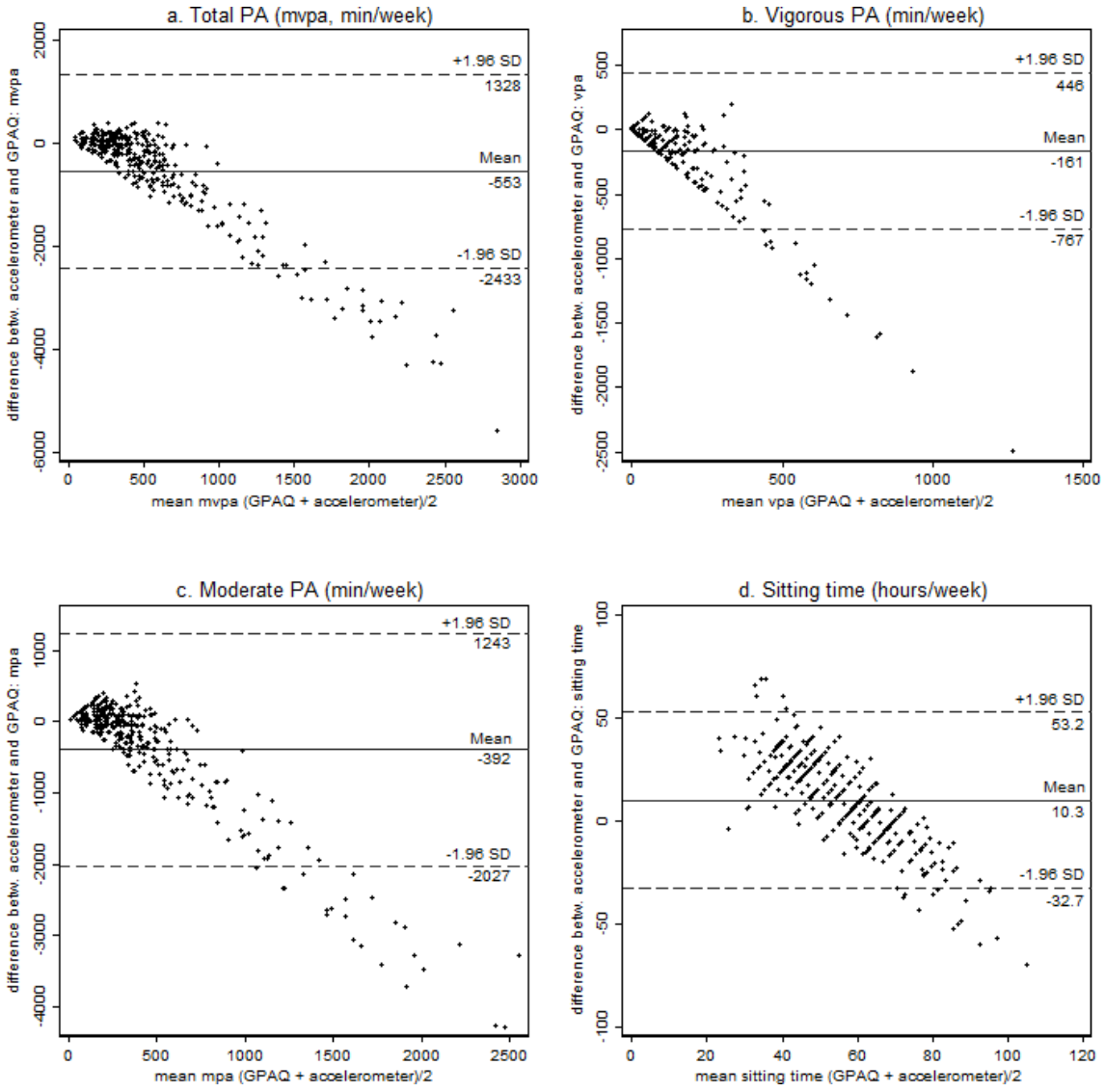

Figure 1 Bland-Altman plots for the agreement of data assessed with accelerometer and with the GPAQ. GPAQ, Global Physical Activity Questionnaire; mpa, moderate physical activity; mvpa, moderate-to-vigorous physical activity; PA, physical activity; vpa, vigorous physical activity.

with a sample size large enough to present subgroup analyses. The correlation coefficients found for physical activity in the present study conducted in Switzerland were in a similar range as reported in other Western countries,[11 12] and slightly higher than reported in low/middle-income countries.[4 8 17] The results indicate fair-to-moderate validity of the GPAQ in a self-administered format in German, French and Italian, except for individuals aged 60 years and older when considering total physical activity. Furthermore, it has to be kept in mind that the absolute values differ between GPAQ and accelerometer assessment, with overall 2.8 times higher values for physical activity according to the GPAQ and the highest overestimation (4.2 times) in the oldest age group.

Correlations were fair when comparing total physical activity from the GPAQ (MET-min/week) with counts/min (r=0.22) or steps/week (r=0.25) based on accelerometers, but lower when comparing min/week spent in moderate-to-vigorous physical activity based on both measures (r=0.11). Regarding intensity of physical activity, the correlations in our sample were generally highest for vigorous physical activity (r=0.46 in total sample), which is similar as reported in other studies.[7 11 18] However, a Vietnamese study did not find any correlations for vigorous physical activity.[8] Like in our study, correlations for moderate physical activity were mostly poor,[4 7 8] with only few studies reporting fair correlations.[11 18] Self-reported moderate physical activity correlated better with accelerometer-measured light activities. This may reflect the problem of estimating the intensity of physical activity. Similar results have been reported in a validation study of the IPAQ.[28]

For sitting time, the moderate/acceptable correlation we found (r=0.47 in the total sample) was higher than reported in other studies,[7 8 12] and it has to be

mentioned that some studies did not find any correlations for sitting time.[4 11] It is possible that the correlation for sitting is higher in our study because of the self-administered format. Participants may have taken more time to think about their sedentary behaviour than in an interviewer format. It is also possible that the example activities were well chosen and supported a more realistic estimation of daily sitting time. Finally, it is probable that a higher proportion of participants in Western countries has a sedentary job, which accounts for a high proportion of total sitting time and may make estimation of sitting time easier. For sitting time, the correlations were fair to moderate in all subgroups in the present study (between 0.21 in the oldest age group and 0.52 in the middle age group), and underestimation in the GPAQ was also acceptable (1.2 times higher according to accelerometers).

Only few other studies reported subgroup analyses mainly based on sex. While Au *et al* found slightly higher correlations for men than for women regarding total physical activity,[9] Cleland *et al* reported similar correlations for total physical activity but significant correlations for sitting time only for women (r=0.38) and not for men (r=−0.05).[12] The significant difference between men and women we found for vigorous physical activity may indicate that men are more likely to overestimate this intensity of physical activity. Regarding sitting time, a remarkable difference was found between the youngest (r=0.61) and both the middle and oldest (r=0.38 and 0.37, respectively) age groups. Younger aged individuals may have more daily routine in sitting with education and sedentary jobs and thus have less problems estimating daily sitting time.

Strengths of the study are the relatively large sample size including individuals from three language regions and a wide age range up to 83 years. Furthermore, the GPAQ was used in a self-administered format, which seems to have become a more commonly used format especially in Western countries. The compliance of the participants was high. A limitation is that the recruitment differed in the Italian-speaking region resulting in a younger population with a higher proportion of men. This has probably mainly influenced the physical activity levels but should not have an impact on the correlations. A limitation that is inherent to accelerometers in general, not only in this study, is that they are not able to provide any information regarding the context of physical activity, and therefore information regarding domains of physical activity from the GPAQ can only be compared with total physical activity measured objectively. Additionally, we used the same cut points to categorise physical activity intensities irrespective of the age of participants, which may be another limitation. It has been suggested that lower cut points should be used for older individuals.[29] However, even though efforts are underway to develop suitable cut points for older adults,[30] most studies have limitations, and up to now most researchers use the well-established cut points also in studies including older adults.[31] Furthermore, correlations can be high even if the absolute values of two measurement methods are different. However, one way to account for that is by showing Bland-Altman plots. Finally, the validation of questionnaires using objective measures was considered as the best level of evidence in a systematic review.[3] Nevertheless, questionnaires and accelerometers are distinct methods and comparison is not straightforward.

Conclusions

Based on the results of the present study, the GPAQ in the self-administered format as used in this study showed fair-to-moderate validity with similar correlation coefficients when compared with studies using the interviewer format. This is true for all language regions, both sexes and the age categories up to 60 years. For those aged 60 years and older, the GPAQ seems to capture well leisure-time physical activity and sitting time, while a careful interpretation of total and moderate physical activity is required. Furthermore, even though the validity is fair to moderate, it needs to be taken into account that the physical activity levels were significantly higher according to the GPAQ than according to accelerometers.

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Contributors MW was involved in the study design, data assessment, data analyses and writing the paper. EM-D was involved in the study design, data assessment and writing the paper. CH was involved in participant recruitment and writing the paper. GP was involved in data assessment and writing the paper. BWM was involved in the study design and writing the paper. MS was involved in participant recruitment and writing the paper.

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Competing interests None declared.

Patient consent We used a patient consent form that adheres to the requirements of the ethics committee of the Canton of Zurich. Each patient gave written informed consent prior to participation.

Ethics approval Ethics Committee of the Canton of Zurich.

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