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RESEARCH

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Correlations between the Japanese version of the Global Physical Activity Questionnaire and accelerometer-measured physical activity and sedentary time in adult women and men

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Abstract

Background Physical activity (PA) and sedentary behaviour have important health implications. Self-reported measures of PA and sitting time (ST) such as questionnaires are most commonly used in public health studies and surveillance, but their accuracy might be affected by cultural differences between countries. The aim of the present study was to examine the correlation between the self-administered Global PA Questionnaire - Japanese version (GPAQ-J) and accelerometer in Japanese adults.

Methods A cross-sectional comparative study was conducted to examine the last 7 days PA by GPAQ-J, comparing with accelerometer data. A convenience sample of 181 women and 85 men were included.

Results Significant positive correlations using Spearman's rank correlation were observed between total moderate-to-vigorous PA (MVPA) by GPAQ-J and both of accelerometer-measured total MVPA and 10-minute bouts of MVPA in both women and men, with a higher correlation in men (total MVPA: $\rho = 0.375$, 10-minute bouts of MVPA: $\rho = 0.419$). GPAQ-J transportation MVPA was significantly correlated with all types of variables for accelerometer-measured MVPA for men, particularly with ambulatory MVPA ($\rho = 0.615$). On the other hand, for women, a significant positive correlation was observed between GPAQ-J recreation MVPA and accelerometer-measured 10-minute bouts of MVPA. Average MVPA with GPAQ-J was between the accelerometer-measured total MVPA and the 10 min bouts of MVPA in both genders. A significant positive correlation was only observed between ST by accelerometer and the GPAQ-J question in men ($\rho = 0.332$), not women ($\rho = 0.004$).

Conclusions The GPAQ-J has weak or moderate validity for evaluating both total and 10-minute bouts of MVPA in Japanese women and men. ST by the GPAQ-J has moderate validity only in men.

Keywords GPAQ, Accelerometer, Gender difference, Physical activity, Validity

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Background

The Ministry of Health, Labour and Welfare of Japan initiated a national health promotion program named "Health Japan 21 (third term)" in 2024 in accordance with Article 7 of the Health Promotion Act [1]. The Health Japan 21 (third term) was uploaded based on the final evaluation of the Health Japan 21 (second term) for the period between 2013 and 2023. In the Health Japan 21 (second term), for physical activity (PA), targets for step counts in 20–64 year-old men were 9,000 steps/day, which was achieved by 36% of men, and 8,500 steps for 20–64 year-old women, which was achieved by 33% of women, respectively [1]. Furthermore, age-adjusted mean PA and exercise prevalence were 7887 steps/day and 24.1% for men and 6671 steps/day and 16.5% for women in 2019, respectively. In the final evaluation of the Health Japan 21 (the second term) in November 2022, there was little change in the PA and exercise status for Japanese adults both men and women. Moreover, the number with metabolic syndrome/ and at-risk of metabolic syndrome in 40–79 years old also increased+8.3% compared to baseline. These data also reveal substantial gender differences in PA in Japan.

For the first time in 2020, a World Health Organization (WHO) recommendation was provided for sedentary behavior (SB), based on associations between SB and health outcomes for adults as well [2]. This was added to evidence-based public health recommendations for adults on the amount of PA required to offer significant health benefits and mitigate health risks [2]. The WHO guideline states that the adults should limit the amount of time spent being sedentary, for substantial health benefits. For PA, the guideline states that adults (aged 18–64 years) should do at least 150–300 min of moderate-intensity aerobic PA; or at least 75–150 min of vigorous intensity aerobic PA; or an equivalent combination of moderate- and vigorous-intensity activity (MVPA) throughout the week. In the guidelines, PA has been defined as "Any bodily movement produced by skeletal muscles that requires energy expenditure". Ainsworth et al. [3] reported many daily activities are applicable to activity over 3METs, as reported by work, household, exercise, sports, leisure time activities, active transportation, volunteer activities and so on.

Self-report questionnaires are most commonly used to measure PA and SB in public health studies and surveys because of the low costs, minimal burden and easy implementation [4–7]. The Global Physical Activity Questionnaire (GPAQ) was developed by WHO and included in several items reflecting work, transportation, leisure time activities, and assessment of daily sitting time (ST) [8]. There have been many different validation studies of the GPAQ by official various language versions in several countries [9–15], but the validity of the GPAQ across all human populations is uncertain. The Japanese version of the GPAQ (GPAQ-J) was developed [16] and the GPAQ-J has been used in various kinds of surveys by companies, research groups, and research foundations for research and local or nation-wide surveys. However, the validity of the GPAQ-J for Japanese adults has not been reported, although there is one paper on the validity of the GPAQ-J for estimating total energy expenditure against the doubly labelled water method [17] rather than the duration of each PA intensity Because PA is a behavior, the cultural environment should be taken into account even when the same PA questionnaire is used in different countries [18, 19]. According to the Organisation for Economic Co-operation and Development (OECD) 2020 data on international comparisons of living time (for men and women aged 15–64), Japanese men's paid working time (7 h 32 min) and unpaid working time (41 min) were significantly higher (5 h 17 min) or lower (2 h 16 min) than the OECD average [20]. In all countries, women worked longer hours of unpaid work, but the male-to-female ratio (the ratio of men to women with men as 1) was particularly large in Japan (5.5 times). This means that Japan has much longer total working time for both men and women. The culture of Japan and cultural differences between other countries and Japan might be attributable in part to the fact that Japanese males may spend more time than other countries males doing activities that are classified as working activities. Such differences in the duration and type in working and household activities between countries may affect the relationship between GPAQ and the accelerometer. Moreover, it is possible that adults in different countries have different ways of perceiving physical activity and that may alter the validity of the GPAQ.

Accelerometers are a widely used method to assess concurrent validity of PA and SB questionnaires [4–7]. In contrast to accelerometers used in those validation studies, the Active style Pro (Omron Healthcare, Kyoto, Japan) is a triaxial accelerometer which can accurately discriminate ambulatory and non-ambulatory activities [21] and predict PA intensity relatively accurately [22]. Recently, a nationally representative survey in Japan has been conducted with the GPAQ-J in the National Sports-Life Survey by the Sasakawa Sports Foundation, but the validity of the measures obtained needs to be assessed. Thus, the present study was the first study to examine the correlation between a Japanese version of the GPAQ-J and the Active style Pro in Japanese adults both women and men.

Methods

Study design and sample

A cross-sectional study was conducted to examine the last 7 days PA and SB by GPAQ-J, compared with the

accelerometer to measure concurrent validity. We analyzed data from parents participating in a previous study [23]. A convenience sample from the parents was 181 adults' women and 85 men with children from 14 primary schools in urban areas of Tokyo and Kyoto. Tokyo is the capital and Kyoto is an ordinance-designated city. Data for anthropometric measurements, PA and SB were collected during the school year between September 2012 and January 2015 (September, October, and November 2012, on April, October, and November 2013, on November 2014, and on January 2015).

Measurement materials and methods

Anthropometry and sociodemographic factors

Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively at schools or employee health checks. Body mass index (BMI) was calculated as body weight (kg) divided by height squared (m^2). Date of birth, employment status (employed or housewives/unemployed) and educational history (years) were asked by the questionnaire.

Japanese version of the Global Physical Activity Questionnaire (GPAQ-J)

The GPAQ was developed by WHO and included in several items reflecting work, transportation, leisure time activities, and assessment of daily ST in a typical week for adults [8]. The GPAQ-J was developed by a scientific research group of the GPAQ [16]. The original version was translated into Japanese and then back-translated into English to confirm the accuracy of the translation.

Physical activity measurements

Habitual PA was measured with a triaxial accelerometer (Active style Pro HJA-350IT, Omron Healthcare, Kyoto, Japan), 74×46×34 mm and 60 g including batteries. Participants wore the accelerometer on the left side of the waist. The characteristics and detailed are described elsewhere [21, 22]. Briefly, the signals obtained from the triaxial accelerometer were processed in the following way: Each of the three signals from the triaxial accelerometer was passed through a high-pass filter with a cut-off frequency of 0.7 Hz to remove the gravitational acceleration component from the signal. From the obtained synthetic acceleration of all three axes using signals before and after high-pass filtering, the ratio of unfiltered to filtered acceleration was calculated to discriminate ambulatory and non-ambulatory activities. The accuracy of the classification of ambulatory and non-ambulatory activities by the unfiltered/filtered acceleration ratio was almost 100% for eleven selected activities including resting in the supine and sitting position and personal computer work [21]. The average of the absolute value of the accelerometer output of each axis from 10 s epochs were used to predict metabolic equivalents. The Active style Pro was set to record in 10 s epochs, and the value of 1-min epoch was calculated as the mean value of physical intensity in 10 s epochs. The Active style Pro recorded predicted MET values and type of PA (ambulatory and non-ambulatory), based on the classification algorithm and 3 different predictive equations for MET values depending on the accelerations and type of PA, described in the calibration papers [21, 22]. Active style Pro has been shown to provide accurate physical activity intensity, even for non-ambulatory activity [22, 24]. As a result, the estimate of total energy expenditure (TEE) was identical to that obtained by the doubly labeled water method, while other accelerometers underestimated TEE substantially [25]. Moreover, Active style Pro provided comparable sedentary time with activPAL for Japanese adults, with a little underestimation (less than 30 min/day), which was a much better result than ActiGraph with a cutoff of 100 or 150 counts per min [26].

PA was monitored continuously for 7–10 days. The period was almost the same as that of 7 days recall covered by GPAQ-J. Participants were requested to wear these devices at all times, except under special circumstances, such as dressing and bathing. We asked participants to wear the accelerometer during sleep in order to reduce non-wear time. As a result, however, wear time included sedentary time and sleep, although participants should have worn the accelerometer longer. Therefore, sleep records obtained by participants were contrasted with acceleration data to determine sleep duration, and estimated sleep duration was removed from the analysis. Periods with over 60 min of consecutive zero-count were considered to be non-wear time. We adopted days in which more than 600 min (10 h) of wear time had accrued, not counting time allowed for the above-mentioned unavoidable reasons. Participants with data from at least 3 days were included in the analysis. The data obtained by the Active style Pro were imported into a PC via BiLink (Omron Healthcare, Kyoto, Japan) and further data processing of the accelerometer was performed using the Excel macro program developed and distributed by the Japan Physical Activity Research Platform [16]. GPAQ Analysis Guide was used for scoring and data cleaning [16], summarizing data in min/week format. Total MVPA min/week (all vigorous+all moderate activities' mins), moderate and vigorous activities in min/week, and weekly ST in min/week values were calculated. The data were checked following the GPAQ Analysis Guide and data regarded as recording errors were excluded from the dataset. Next, data not included in the median ± 1.5 times IQR were excluded as outliers.

Analyses

We operationalized SB as average number of minutes spent in ST by the accelerometer: 1.5≦metabolic equivalents (METs), moderate intensity activity: 3≦METs < 6, vigorous intensity activity: 6≧METs, and MVPA: 3≧METs was calculated for each individual. PA assessed by the accelerometer is presented as PA states for ambulatory activity or non- ambulatory activity in intensity-specific categories (light intensity activity, MVPA). The associations between ST or PA variables using accelerometer and each domain by the GPAQ-J were analyzed by analysis of Spearman correlation coefficients (ρ). To present the quantitative data, mean (standard deviation, SD) and median (inter quartile range, IQR) were computed. Normality of the data was tested using Kolmogorov-Smirnov test (data was considered normally distributed if $p<0.05$). Mann-Whitney U test and Cramer's V-square were calculated to measure the gender differences in PA levels. All results are shown as means and standard deviations (SDs). Statistical analyses were performed with SPSS version 28.0 J for Windows (IBM Japan, Tokyo, Japan). Confidence interval of 95% was applied, and p value of <0.05 was considered statistically significant.

Results

The initial parents' sample comprised 608 participants. Due to insufficient accelerometer data ($n=40$), no data from their child ($n=151$), withdrawal of consent ($n=9$), history of conditions affecting PA, such as respiratory disease or heart disease ($n=17$), different ethnic group ($n=3$), and pregnancy ($n=1$), missing data in GPAQ-J ($n=34$), outliers through data cleaning in GPAQ-J ($n=82$) and no data from questionnaire other than GPAQ-J ($n=5$), the final study sample comprised data from 266 adults.

The main characteristics of the sample are shown in Table 1. The women and men participants significantly differed by anthropometric measures (body height, body weight, BMI) (women<men). Comparing the accelerometer-measured data for women and men, we found significant differences in MPA, 10-minute bouts of MVPA (women<men), and ST, but MVPA and VPA did not differ significantly. Women had lower ambulatory MVPA, but higher non-ambulatory MVPA. GPAQ-J data showed significant differences among women and men in total MVPA due to higher Work MVPA and Transport MPA in women and ST (women<men). Average MVPA time obtained with GPAQ-J was between the accelerometer-measured total MVPA and the 10 min-bouts of MVPA in both women and men.

Table 2 shows that a significant positive correlation was found between accelerometer-measured MVPA and GPAQ-J total MVPA and 10-minute bouts of MVPA in both women and men. For women, a significant correlation was observed only between GPAQ-J recreation MVPA and accelerometer-measured 10-minute bouts of MVPA. On the other hand, for men, GPAQ-J transportation MVPA was significantly correlated with all types of variables for accelerometer-measured MVPA, particularly with ambulatory MVPA (ρ=0.615). In addition, GPAQ-J Work MVPA and accelerometer-measured bouts of MVPA was weakly, but significantly correlated. As a result, GPAQ-J total MVPA was significantly correlated with accelerometer-measured total MVPA (ρ=0.375) and bouts of MVPA (ρ=0.419), and the correlations were higher than in women (ρ=0.165 and ρ=0.182, respectively). A significant positive correlation was found between ST by accelerometer and the GPAQ-J question on ST in men (ρ=0.335), but not in women (ρ=0.004), although average ST obtained with the GPAQ-J was much lower than the accelerometer-measured ST in both women and men.

Discussion

This study showed acceptable validity of the GPAQ-J compared to the accelerometer data, particularly for MVPA in men, based on the correlations with accelerometer according to MPA, VPA, MVPA, and ST values. Our results are consistent with most other studies according to the intensity of the correlation coefficients. ST by the GPAQ-J was only moderately correlated with accelerometer data in terms of sedentary time (minutes per day) in men.

This study is the first to examine the validity of the GPAQ-J in comparison with accelerometer data in Japanese adults. Systematic reviews have reported that concurrent validity of the GPAQ using accelerometers ranged from poor to fair [4, 27]. Rank correlations between accelerometer and GPAQ may vary by country/culture: some researchers reported higher correlations for minutes of MVPA in the US ($r=0.26$), China ($r=0.26$–0.52), and the UK ($r=0.48$) than that found by Bull and colleagues in lower-income countries such as South Africa (r = -0.03). The correlations for men obtained in the present study were approximately comparable to those obtained in high-to-middle income countries such as US, China and the UK, but slightly lower in women.

There are several previous studies on the differences among women and men in validity of GPAQ. For example, in the Hungarian GPAQ validation study, only MVPA showed moderate validity compared to the accelerometer data ($r=0.264$; $p=0.0497$ for men and $r=0.291$; $p=0.020$ for women), but there were no significant differences between the sexes in the validity of ST measurement [28]. Cleland et al. [29] reported similar moderate correlations for criterion validity for females ($r=0.434$; $p=0.010$) and males ($r=0.496$; $p=0.005$) in MVPA in the UK. The

Table 1 Descriptive characteristics of participants

	Women (*n*: 181)			Men (*n*: 85)			Mann–Whitney's U	*p*-value
	Median	IQR	Mean±SD	Median	IQR	Mean±SD		
Age (years)	41.5	39.2 -44.6	41.8 ±3.9	43.3	40.5 -46.5	43.5 ±4.3	22409.0	0.003
Height (cm)	158.9	154.8 -162.9	158.8 ±5.3	171.0	167.7 -175.4	171.7 ±5.5	17090.0	<0.001
Weight (kg)	52.3	48.4 -56.5	52.7 ±6.4	68.0	62.0 -73.0	68.3 ±9.7	17732.5	<0.001
Body Mass Index (kg/m^2)	20.5	19.0 -22.2	20.9 ±2.6	23.3	21.7 -24.7	23.2 ±3.1	20515.0	<0.001
Weight status	(%)	(n)		(%)	(n)		Cramer's V	
Obesity	6.1	11		20.0	17		0.261	<0.001
Normal weight	79.6	144		74.1	63			
Underweight	14.4	26		5.9	5			
Employment status								
Housewife	70	39		0	0		0.427	<0.001
Employed	101	56		81	95			
Unanswered	10	6		4	5			
Educational history								
Junior high/high school	25	14		14	16		0.237	0.001
Junior college	59	33		9	11			
Universities/graduate school	92	51		58	68			
Unanswered	5	3		4	5			
GPAQ-J								
Work								
MPA (min/wk)	60.0	0.0 -300.0	177.3 ±238.0	0.0	0.0 -0.0	28.8 ±59.4	8080.0	<0.001
VPA (min/wk)	0.0	0.0 -0.0	5.7 ±33.8	0.0	0.0 -0.0	0.4 ±3.3	10927.5	0.055
MVPA (min/wk)	60.0	0.0 -300.0	183.0 ±245.0	0.0	0.0 -0.0	29.2 ±59.3	8092.0	<0.001
Transport								
MPA (min/wk)	120.0	30.0 -217.5	145.1 ±130.7	75.0	0.0 -177.5	107.1 ±123.4	9776.0	0.007
Recreation								
MPA (min/wk)	0.0	0.0 -7.5	19.2 ±36.8	0.0	0.0 -35.0	30.6 ±61.0	23732.0	0.341
VPA (min/wk)	0.0	0.0 -0.0	4.6 ±19.2	0.0	0.0 -0.0	15.1 ±45.9	23567.0	0.040
MVPA (min/wk)	0.0	0.0 -45.0	23.8 ±41.6	0.0	0.0 -70.0	45.7 ±79.7	23488.0	0.156
Total MVPA (min/wk)	270.0	130.0 -500.0	351.9 ±294.2	150.0	72.5 -285.0	181.9 ±153.9	8668.0	<0.001
Sitting time (min/day)	240.0	120.0 -360.0	261.7 ±174.1	360.0	240.0 -600.0	433.2 ±248.7	20944.5	<0.001
Accelerometer								
Ambulatory								
MPA (min/day)	29.0	20.0 -44.0	32.4 ±18.0	43.0	28.5 -56.5	43.2 ±19.9	21580.5	<0.001
VPA (min/day)	0.0	0.0 -1.5	1.5 ±3.5	0.0	0.0 -2.0	2.6 ±5.2	24121.5	0.938
MVPA (min/day)	30.0	20.5 -46.0	33.9 ±19.5	45.0	30.5 -58.5	45.8 ±21.7	21551.5	<0.001
Non-ambulatory								
MPA (min/day)	33.0	23.0 -47.0	38.9 ±24.6	13.0	8.0 -23.5	17.8 ±14.1	6370.0	<0.001
VPA (min/day)	0.0	0.0 -0.0	0.0 ±0.1	0.0	0.0 -0.0	0.0 ±0.2	24067.5	0.436
MVPA (min/day)	33.0	23.0 -47.0	38.9 ±24.6	13.0	8.0 -23.5	17.8 ±14.1	6375.0	<0.001
Total								
MPA (min/day)	65.0	51.0 -87.0	71.2 ±33.2	59.0	45.5 -73.5	60.9 ±23.0	10081.5	0.030
VPA (min/day)	1.0	0.0 -2.0	1.5 ±3.5	0.0	0.0 -2.0	2.6 ±5.2	23979.0	0.736
MVPA (min/day)	66.0	51.5 -90.0	72.8 ±33.9	61.0	48.0 -77.5	63.6 ±24.4	10287.5	0.070
Bout MVPA (min/day)	10.2	4.4 -19.5	7.1 ±5.3	17.1	5.5 -30.1	8.5 ±5.6	22756.0	0.016
Sedentary time (min/day)	472.0	419.0 -534.0	476.9 ±89.2	584.0	505.5 -679.5	587.6 ±121.4	20036.0	<0.001

Abbreviations GPAQ-J the Japanese version of the Global Physical Activity Questionnaire, MPA moderate physical activity, VPA vigorous physical activity, MVPA moderate-to-vigorous physical activity, Bout MVPA 10-minutes bout of MVPA, IQR Inter quartile range, SD Standard deviation

accelerometer and questionnaire ST data showed fair level correlations for females (r=0.378; p=0.027) but a poor correlation for males (r=−0.053; p=0.778). Mumu et al. [14] found fair to moderate correlations between objective and subjective monitoring in Bangladesh (Women: r=0.42 for MVPA, p<0.01, Men: r=−0.10 for MVPA, ns). Thus, most previous studies have found little gender difference in the relationship between GPAQ and MVPA, or a stronger correlation for women. In contrast, in the present study, MVPA and ST for men correlated

Table 2 Spearman's rank correlations between self-reported and accelerometry-recorded levels of physical activity and sedentary time

	Women	GPAQ-J				
		Work MVPA	Transport MPA	Recreation MVPA	Total MVPA	Sitting time
Accelerometer	Sedentary time					0.004
	Total MVPA	0.083	0.132	0.055	0.165*	
	Ambulatory MVPA	0.080	0.023	0.017	0.097	
	Non-ambulatory MVPA	0.044	0.131	0.109	0.133	
	Bout MVPA	0.111	0.109	0.178*	0.182*	
	Men	GPAQ-J				
Accelerometer	Sedentary time					0.335**
	Total MVPA	-0.053	0.417**	0.094	0.375**	
	Ambulatory MVPA	-0.178	0.615**	0.063	0.461**	
	Non-ambulatory MVPA	0.099	-0.215*	0.104	-0.073	
	Bout MVPA	-0.214*	0.571**	0.084	0.419**	
	Whole sample	GPAQ-J				
Accelerometer	Sedentary time					0.217**
	Total MVPA	0.080	0.029	0.080	0.229**	
	Ambulatory MVPA	-0.089	0.033	-0.086	0.169**	
	Non-ambulatory MVPA	0.229**	0.066	0.230**	0.076	
	Bout MVPA	-0.060	0.152*	-0.051	0.193**	

Spearman's rho (95%CI), Abbreviations: GPAQ-J the Japanese version of the Global Physical Activity Questionnaire, MVPA moderate-to-vigorous physical activity, MPA moderate physical activity, Bout MVPA 10-minutes bout of MVPA, * $p<0.05$, ** $P<0.001$

better with accelerometer output than did those for women. This may be due to the context specific nature of activities. Many household activities correspond to activity of 3METs or more, as reported by Ainsworth et al. [3], carpet sweeping, sweeping floors, mopping, vacuuming, carpentry, bagging grass, etc. while childcare is reported as 2.0 to 3.0 METs. The inconsistency between women and men in the present study might be attributable in part to the cultural context in Japan- possibly the fact that women spend more time than men doing activities that are classified as household activities. According to data from the Basic Survey of Social Life of the Ministry of Internal Affairs and Communications, Japanese men spend an average of 1 h 23 min a day on housework and childcare (including 49 min on childcare), compared with 7 h 34 min a day (including 3 h 45 min on childcare) in women [30]. On the other hand, in Norway, men and women spend an average of 3 h 12 min or 5 h 26 min a day on housework and childcare, respectively (including 1 h 13 min or 2 h 17 min on childcare, respectively). This cultural difference leads to a large gender gap in Japan in the types and durations of PA.

Of particular importance is that MVPA time evaluated by GPAQ-J was correlated with not only 10-minute bouts of MVPA, but also total MVPA time by accelerometer. The GPAQ-J reports 10-minute bouts of MVPA. According to the new WHO guidelines on PA and SB [2], however, the recommendation for bouts of least 10 min duration has been removed. It is suggested that the GPAQ-J reflects, to some extent, the relative amount of total MVPA time, although it should be noted that the MVPA time obtained by the GPAQ-J was between the total MVPA time and 10-minute bouts of MVPA by the accelerometer.

The correlations between ambulatory, non-ambulatory or total MVPA and each domain PAs were also evaluated in the present study. Only transport PA had moderate correlations for ambulatory MVPA ($\rho=0.615$) and total MVPA in males ($\rho=0.417$). On the other hand, for the other PA domains GPAQ-J data from both females and males were not correlated significantly with criterion values. Household activities consist mainly of non-ambulatory activity and may be more difficult to recall than ambulatory activity. Time spent in transport PA in males was significantly longer than that of women. Men were more likely to walk at work, and as a result, MVPA at work was easier to capture, possibly resulting in stronger correlations for men.

There are limitations to consider in the interpretation of these results. First, the participants in the present study were only mothers and fathers, and the sample size was relatively small, which limits the generalizability of the results. However, the majority of adults were also parents, and the body size of the participants in the present study was close to the averages of Japanese adults. On the other hand, the employment rate in Japan for those aged 35–44 was 93.2% for men and 71.2% for women in 2015 [31]. The survey population has a lower female employment rate and a higher male employment rate by approximately 10 points compared to the national survey. 51% of women and 72% had a high level of educational history. Thus, socio economic status of participants was

considered to be relatively favorable. Second, accelerometers do not register movement during cycling and swimming time and were not worn all day. Third, the results of the present study may be applicable only to Japanese adults in an urban area. Finally, we could not collect reliability data for the participants because of the need to minimize participant burden. However, the Japanese results confirmed that GPAQ-J may be a valid tool to examine the Japanese adult's level of not only 10-minute bouts of MVPA, but also total MVPA time. This study, which examined the correlation between the GPAQ developed by WHO for Japanese adults and the results obtained by an accelerometer, might allow international comparisons of PA and ST, which would therefore contribute to surveillance systems and inform policy in the world including Japan.

Conclusions

The purpose of the present study was to validate the GPAQ-J against accelerometer in Japanese adults. Significant positive correlations using Spearman's rank correlation were observed between total MVPA by GPAQ-J and both of accelerometer-measured total MVPA and 10-minute bouts of MVPA in both women and men, with a higher correlation in men, particular due to the moderate association between GPAQ-J transportation MVAP and ambulatory MVPA by accelerometer. For women, a significant positive correlation was observed between by GPAQ-J recreation MVPA and accelerometer-measured 10-minute bouts of MVPA. A significant positive correlation was only observed between ST by accelerometer and the GPAQ-J question in men, not women. Thus, the GPAQ-J has weak or moderate validity for evaluating both total MVPA and bouts of MVPA in Japanese women and men and may be used for relative assessment of MVPA in such a population. ST by the GPAQ-J has moderate validity only in men.

Abbreviations

GPAQ	J-Global PA Questionnaire-Japanese version
GPAQ	Global Physical Activity Questionnaire
IQR	Inter quartile range
METs	Metabolic equivalents
MVPA	moderate-to-vigorous physical activity
PA	Physical activity
SB	Sedentary behavior
SD	Standard deviation
SDs	Standard deviations
ST	Sitting time
WHO	World Health Organization

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Author contributions

CT: Conceptualization, Methodology, Investigation, Data curation, Writing-Original draft preparation, Funding acquisition. JJR: Methodology, Writing-Reviewing and Editing, Supervision.: ST: Formal analysis, Funding acquisition, Writing- Reviewing and Editing.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The Ethical Committee of J. F. Oberlin University (Approval no: 12023) approved the study protocol. Participate consent and permission assent were obtained prior to participation.

Consent for publication

Not applicable.

Competing interests

Prof. Shigeho Tanaka received consigned research funds from Omron Healthcare Co., Ltd. The remaining authors declare no competing interests.

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