PUBLIC HEALTH RESEARCH

Reliability and Validity of Malay Language Version of International Physical Activity Questionnaire (IPAQ-M) among the Malaysian Cohort Participants

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ABSTRACT

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Introduction Validation of instruments is essential when assessing physical activity (PA). The aim of this study was to validate a Malay language version of the International Physical Activity Questionnaire (IPAQ-M) against Actical accelerometer and to determine its reliability and validity.

Methods A total of 90 Malay adults aged 35-65 years old participating in The Malaysian Cohort project were recruited for this study. The IPAQ-M is comprised of 12 items, covering vigorous, moderate, walking, sitting and sleeping activities, and was administered on two occasions (Day 1 and Day 9) by interviewing the participants. Participants wore the Actical accelerometer for seven consecutive days between the two interview sessions.

Results Validity tests showed that time spent in moderate-vigorous physical activity (MVPA) (min wk^{-1}) from IPAQ-M was significantly correlated with MVPA from accelerometer (ρ=0.32, $p<0.01$). Time spent in vigorous activity (ρ=0.44) and total activity (ρ=0.36) from IPAQ-M were significantly correlated ($p<0.01$) with that measured by accelerometer, but no correlation was observed for sedentary behaviour. Reliability tests revealed significant correlations between the two interview sessions for all intensities of PA (ρ=0.55 to 0.71, $p<0.01$). Bland-Altman plots showed that time spent in MVPA for IPAQ-M was significantly different from that measured by accelerometer (mean difference: 98.02 min wk^{-1}; 95% limits of agreement: -785.33 to 1317.83 min wk^{-1}; $p<0.01$). When classifying people into meeting PA recommendation, the agreement between the two instruments was fair (κ=0.22).

Conclusions The IPAQ-M has acceptable validity for MVPA, vigorous and total physical activity, and was reliable for assessing the physical activity of Malay adults.

Keywords Health care workers - Knowledge - Practice - Universal precaution - Health center.

INTRODUCTION

Physical activity (PA) is an important component of a healthy lifestyle and it influences the health and wellness of individuals. The importance of physical activities in terms of enhancing health and reducing the risk of chronic diseases has been widely documented[1,2]. The World Health Organisation (WHO) estimated that overall physical inactivity caused 3.2 million deaths annually[3]. The Global Burden of Disease (GBD) 2010 study reported that the causes related to physical inactivity (cardiovascular disease, diabetes, and certain cancers) account for 39.6% of the 12.8 million deaths in those aged 15 years and older. In developing countries, these causes account for only 22.2% of the 32.3 million deaths among those aged 15 years and older[4]. Overall, the prevalence of physical inactivity in Malaysia is 43.7%, with 35.3% men and 50.5% women being classified as inactive[5].

According to Ainsworth[6], many different methods are available for assessing physical activity, including objective (such as doubly labeled water, accelerometers, heart rate monitors) and subjective (such as questionnaires, diaries, observation) measurements. Normally, in epidemiological studies, questionnaires are often employed because they are more cost-effective and easily administered to a large population[7]. A good instrument should be accurate, objective, precise, robust, simple to use, socially acceptable, applicable to large population groups, and most importantly allows continuous and detailed recording of usual activity patterns[8]. According to Bonomi et al.[9], PA should be measured in free-living conditions with minimal discomfort to the participant. In this context, accelerometers are considered the preferred method for objective measurement of physical activity, and accelerometry is considered a criterion that can be used for the validation of other measures of physical activity[10].

In 1996, a group of experts formed an International Consensus Group and provided a set of well-developed instruments that can be used internationally, known as the International Physical Activity (IPAQ)[11]. It was designed to overcome the differences in PA measurements but has to be further validated as IPAQ is a relatively new instrument. Other instruments mainly focused on leisure time PA (LTPA)[12]. The IPAQ is available in short and long versions and can be either self-administered or telephone-administered. The short version assesses physical activity over the last seven days, while the long version is used to assess usual physical activity. It has also been translated into many languages, including Malay.

The World Health Survey[13] conducted in year 2003, using the IPAQ, reported that Malaysian adult men (with a median of 5,172 MET-minutes per week) were physically more active compared to their female counterparts (with a median of 1,878 MET-min wk^{-1}). Previous studies had only focused on the overall data of PA without giving any information on PA pattern, frequency and duration of all intensities of activity. In developing countries, epidemiological studies on PA faced challenges, as there is a lack of culturally relevant tools in indigenous languages. In Malaysia, Chu and Moy validated the Malay version of the IPAQ[14]; however, the comparison method was physical activity log, and not a criterion method such as accelerometer.

In order to achieve its aim of building a database of information on the Malaysian population, The Malaysian Cohort requires a suitable tool for the assessment of physical activity levels and patterns of the cohort participants. The Malaysian Cohort is a national project endorsed by the Malaysian government and funded by the Ministry of Science, Technology and Innovation. The cohort was initiated in the year 2005 and aimed to recruit 100,000 participants aged 35 – 70 years throughout Malaysia[15]. Its main objective is to build a rich database and a bio-specimen bank as a platform for the studies of genes, environment and lifestyles in various diseases. As physical activity is an important part of lifestyle, the availability of a valid and reliable tool to accurately assess physical activity is essential in the effort of building The Malaysian Cohort database.

Hence, the aim of the present study was to validate a modified IPAQ in the Malay language (IPAQ-M) against the Actical accelerometer for assessing the physical activity level of middle-aged population sampled from The Malaysian Cohort project, as well as to determine the reliability of the modified IPAQ-M.

METHODOLOGY

Participants and study design

A total of 90 Malay participants aged between 35 to 65 years old from The Malaysian Cohort participated in this validation study. Subjects were from both urban (Kuala Lumpur, Selangor, Melaka) and rural areas (Pahang, Negeri Sembilan, Johor, Terengganu) of Peninsular Malaysia. Any individual with a disability that prevented movement or independent walking was not eligible for this study. Subjects were randomly selected from volunteers who agreed to provide additional informed consent for this study, over and above that provided to participate in The Malaysian Cohort. Ethics approval was obtained from the Medical Research and Ethics Committee of Universiti Kebangsaan Malaysia.

Demographic characteristics, including age and education level, were obtained from a set of questionnaire on Day 1 of the study. Body weight and height of the participants were

measured using a SECA digital weighing scale Model 800 (SECA, Germany) and a portable Harpenden stadiometer (Holtain Limited, UK), respectively. The IPAQ-M was interview-administered in the Malay language and all participants self-reported their physical activity. Test-retest reliability was conducted by administering the IPAQ-M twice with an interval of one week between the two administrations. To assess validity, we examined the agreement between the IPAQ-M and the Actical accelerometer, which was adopted as the criterion method. Participants were instructed on how to wear the Actical accelerometer, which was set to record physical activity from Day 2 onwards. Participants were met for the second time on Day 9, when the activity monitor was collected and a second interview of the same version of the modified IPAQ was administered.

IPAQ-M Instrument

The IPAQ-M consists of questions related to vigorous, moderate, walking, sitting and sleeping activities. Appropriate cultural adaptations were made and translation and back-translation from the original English version of the IPAQ was done following the procedures recommended by the International Consensus Group[16]. The participants were interviewed and provided with relevant examples of moderate and vigorous intensity activities to help them recall all their activities at appropriate intensity levels[17].

The IPAQ-M records the frequency and duration of time spent in vigorous-intensity, moderate-intensity, walking as well as sedentary activities, namely sitting and sleeping. Participants were required to report the activities performed during the last seven days and to include only activities that lasted 10 minutes or more per session.

The total amount of time was then used to classify the participants as either 'sufficiently active' (specificity) or 'insufficiently active' (sensitivity) according to their ability to meet the physical activity guidelines of the 2010 Malaysian Ministry of Health (MOH), which was to accumulate at least 30 minutes of moderate PA on at least five to six days a week, preferably daily[18].

Actical Accelerometer Instrument

PA was measured objectively using the Actical activity monitors (Mini Mitter Co., Oregon, USA), which are lightweight (17g), small (28 x 27 x 10mm), water-resistant and have large data storage capacity[19]. The Actical is an omnidirectional accelerometer that senses motion in all directions. A total of 12 units of the Actical were calibrated before use, tested on participants, were programmed to record data over 60-second epochs, and a unit was secured at the waist of each participant using an elastic band. The participants were instructed verbally and in writing on the way to handle and wear the accelerometer for seven consecutive days.

The participants were asked to wear the accelerometer during their waking hour with the option to remove the device when sleeping and showering. Data were considered a "full day of wearing" if participants had recorded data for at least ten hours of continuous monitoring from the first to the last burst of activity data and could include a single two-hour period of no activity[20]. A minimum of four recording days, including at least one weekend day, reflect one-week's worth of PA of the participant[17,21].

The raw activity data for each participant were exported into Microsoft Office Excel 2007 programme for conversion of activity counts to minute-by-minute activity energy expenditure (AEE, kcals kg^{-1} min^{-1}) based on Heil's algorithm[22]. AEE cut-off points were then used to categorize AEE obtained into three different PA intensities, corresponding to the following: (1) sedentary/light intensity < 0.0310 kcals kg^{-1} min^{-1}; (2) 0.0310 kcals kg^{-1} min^{-1}≤ moderate intensity < 0.0832 kcals kg^{-1} min^{-1}; and (3) vigorous intensity ≥ 0.0832 kcals kg^{-1} min^{-1}. Data cleaning was done to ensure that the time spent daily on each PA comprising of vigorous, moderate and walking activity ranged between 10 to 180 minutes for all participants[16].

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS version 16.0) (IBM, USA). A two-tailed hypothesis was used for all statistical analyses with an alpha level set at 0.05. The normality of the frequency distribution of all the continuous variables was evaluated by the Kolmogorov-Smirnov statistics and all physical activity scores were strongly skewed which indicated that the data were not normally distributed. Differences between measurements were analysed using Wilcoxon analysis.

The non-parametric Spearman correlation coefficient (ρ) was used to test the association between the two administrations of IPAQ-M to check for test-retest reliability, as well as between IPAQ-M (MET min wk^{-1}) and accelerometer-determined physical activity (min wk^{-1}) to check for validity of questionnaire. Agreement between the IPAQ-M and accelerometer at the same intensity levels was assessed with a modified Bland-Altman technique[23]. Variables used for the Bland-Altman analysis were weekly time spent in MVPA activity according to the IPAQ-M versus Actical accelerometer. In addition, the number of participants (in percent) was classified either as meeting or not meeting the 2010 MOH physical activity guidelines, was assessed with Kappa

measures of agreement, and sensitivity and specificity was calculated according to Ekelund et al.[24].

RESULTS

Table 1 shows the physical and socio-demographic characteristics of the participants. Mean age of the participants was 52.6 ± 6.6 years, with a composition of more women (56%) than men (44%), and more rural (54%) than urban (46%) population. Mean BMI was 26.1 ± 4.6 kgm^{-2}, with more than half of the participants were either overweight or obese (57%) and only 6% were underweight.

Table 1 Socio-demography and physical characteristics of participants (n = 90)

	n (%)	Mean ± SD
Age (years)		52.6 ± 6.6
35-44	10 (11)	
45-54	52 (58)	
55-65	28 (31)	
Sex		
Male	40 (44)	
Female	50 (56)	
Location		
Urban	41 (46)	
Rural	49 (54)	
Education		
Primary	35 (39)	
Secondary	38 (42)	
Tertiary	17 (19)	
Employed		
Yes	55 (61)	
No	35 (39)	
Weight (kg)		65.5 ± 12.4
Height (m)		158.7 ± 8.2
Body mass index[a]		26.1 ± 4.6
Under weight	5 (6)	
Normal weight	33 (37)	
Overweight	38 (42)	
Obese	14 (15)	

According to the IPAQ-M, the average total activity reported by participants was 1866 MET-min wk^{-1} (Table 2). Comparison between IPAQ-M and accelerometer showed that for MVPA (p=0.53) and moderate activity (p=0.51), the results did not show any significant differences between the two instruments. However, for other sub-components of activity namely sedentary, total activity, moderate and walking, and vigorous, there were significant differences (p<0.05) between the two methods. The median total daily duration of activity from IPAQ-M was 484 min wk^{-1}, which included 110 min wk^{-1} of walking and 374 min wk^{1} of moderate-intensity activity. The Actical accelerometer data recorded more sedentary time (9,748 min wk^{-1}) compared to IPAQ-M (6,300 min wk^{-1}).

Table 2 Comparison of physical activities as measured by IPAQ-M and accelerometer, median (IQR)

	Median (IQR)		Median (IQR)	Between group *p*- value
IPAQ-M		**Accelerometer**		
Vigorous (min wk^{-1})	0 (0)	Vigorous (min wk^{-1})	0 (0)	0.04

Moderate (min wk^{-1})	374 (536)	Moderate (min wk^{-1})	325 (320)	0.51
Moderate and walking (min wk^{-1})	484 (669)	Moderate (min wk^{-1})	325 (320)	<0.01
MVPA (min wk^{-1})	376 (536)	MVPA (min wk^{-1})	330(320)	0.53
Total (MVW min wk^{-1})	484 (669)	MVPA (min wk^{-1})	330(320)	<0.01
Total activity **(**MET min wk^{-1})	1,866 (2,586)	Total activity (counts)	414,849 (286,666)	<0.01
Sit and sleep (min wk^{-1})	6,300 (1,298)	Sedentary (min wk^{-1})	9,748 (323)	<0.01

All activities in minutes per week unless indicated otherwise.
min = minutes, wk = week
MVPA = Moderate and vigorous physical activity
MVW = Moderate, vigorous and walking activity
MET = Metabolic Energy Turnover

Table 3 showed the correlation between the IPAQ-M and accelerometer. Time spent in MVPA and vigorous activities were significantly and positively correlated with similar activities as measured by Actical accelerometer. Similarly, the IPAQ-M time spent in MVPA and total activities (MET-min wk^{-1}) were each significantly and positively correlated with accelerometer-recorded time spent in moderate activity. In addition, MVPA from the accelerometer was significantly correlated with total activities (MET-min wk^{-1}) in IPAQ-M. Furthermore, time spent in sedentary activity as measured by the accelerometer showed that it was significantly and inversely correlated with vigorous activity, MVPA and total activities (MET-min wk^{-1}) in IPAQ-M.

Table 3 Validity-test between IPAQ-M and accelerometer using Spearman correlation (ρ)

	IPAQ-M				
Intensities (Accelerometer)	Vigorous	Moderate	MVPA	Sit and sleep	Total (MET)
Vigorous	0.44**	0.08	0.19	0.01	0.19
Moderate	0.04	0.20	0.32**	-0.15	0.31**
MVPA	0.05	0.20	0.32**	-0.15	0.31**
Sedentary	-0.24*	-0.19	-0.30**	0.13	-0.30**
Total activity counts	0.03	-0.01	-0.01	0.07	0.36**

Spearman correlation: * p<0.05 , ** p<0.01
All activities in minutes per week, except total activity counts.
MVPA = Moderate and vigorous physical activity

The test-retest reliability data for the IPAQ-M are presented in Table 4. Moderate to strong relationships were observed in the IPAQ-M questionnaire when applied on two different occasions (Day 1 and Day 9). Overall, all activities provided reasonably acceptable reliability ranging from ρ=0.55 to ρ=0.71 (p<0.001).

Table 4 Test-retest reliability based on administration of IPAQ-M on Day 1 and Day 9

Intensity	ρ
Sitting (min wk^{-1})	0.55**
Sleeping (min wk^{-1})	0.59**
MVPA (min wk^{-1})	0.60**
Total (MET-min wk^{-1})	0.62**
Walking (min wk^{-1})	0.56**
Moderate (min wk^{-1})	0.61**
Vigorous (min wk^{-1})	0.71**

Spearman correlation: ** p < 0.01
min = minutes, wk = week
MET = Metabolic Energy Turnover

Figure 1(a) illustrates the time spent in moderate activity (min wk^{-1}) as assessed by the IPAQ-M and accelerometer. The mean difference between the two methods is small (98.05 min wk^{-1} or 14 min day^{-1}), but the 95% limits of agreement are wide (-781.97 to 1318.21 min wk^{-1}). Similarly,

Figure 1(b) also shows that the mean difference for MVPA is small (98.02 min wk^{-1} or 14 min day^{-1}) and the limits of agreement are wide, ranging from (-785.33 to 1317.83 min wk^{-1}).

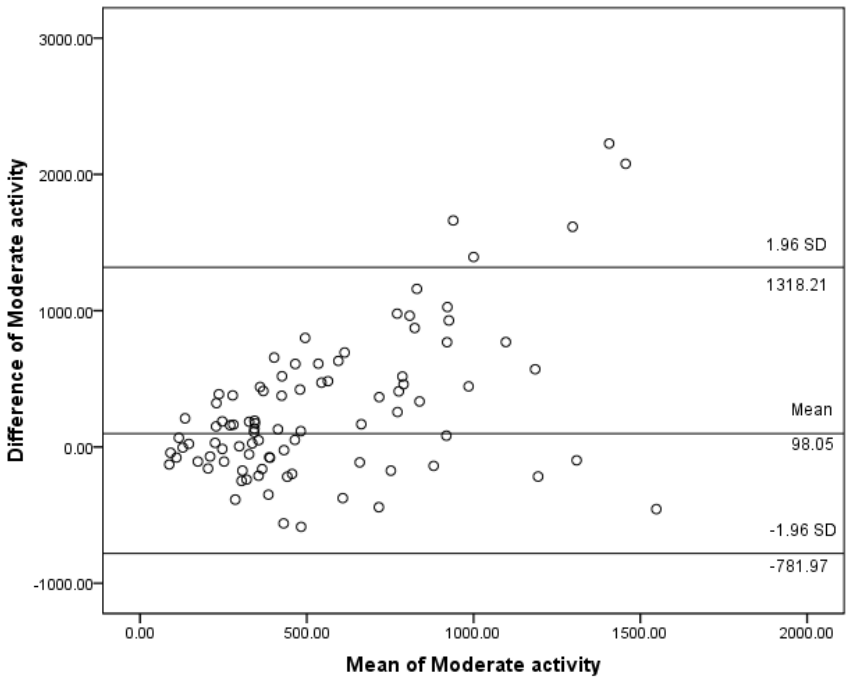

Figure 1 (a) Bland-Altman plot for time spent in at least moderate physical activity (min wk^{-1}) as assessed by the IPAQ-M and measured using Actical accelerometer. Mean difference: 98.05 min wk^{-1} ± 2SD (standard deviation), -781.97 to 1318.21 min wk^{-1} (not significant)

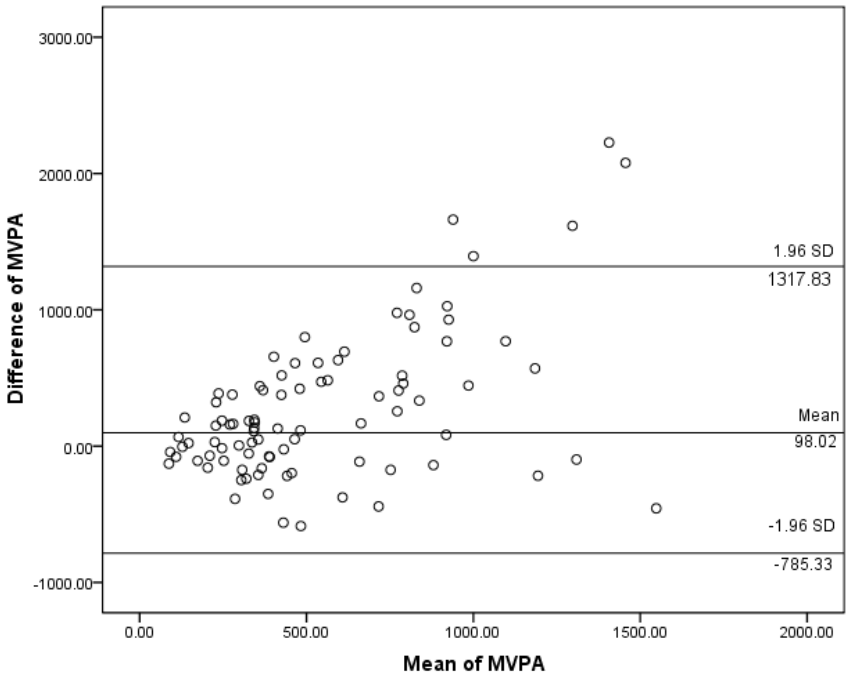

Figure 1(b) Bland-Altman plot for time spent in MVPA (min wk^{-1}) as assessed by the IPAQ-M and measured using Actical accelerometer. Mean difference: 98.02 min wk^{-1} ± 2SD (standard deviation), -785.33 to 1317.83 min wk^{-1} (not significant)

Table 5 shows the categories of participants based on whether they meet PA recommendations. A total of 86% of the participants met physical activity

recommendations[18] based on accelerometry data, while 92% did based on IPAQ-M. 88% of the participants were correctly classified based on the Actical and IPAQ-M.

Table 5 Number (%) of participants classified as being sufficiently active according to PA guidelines by IPAQ-M and by accelerometer (n=90)

Meeting PA guidelines, Accelerometer	Meeting PA guidelines, IPAQ-M			
	No	Yes	Total	Agreement (Kappa)
No	3 (43)	10 (12)	13 (14)	0.22
Yes	4 (57)	73 (88)	77 (86)	

DISCUSSION

To the best of our knowledge, this was the first study to determine the test-retest reliability and absolute validity of the IPAQ-M using accelerometer as the criterion method among Malay adults comprising of dwellers from rural and urban areas. In the validity study of IPAQ-M, all 90 participants wore the accelerometer for the minimum required time period over a week, that is 58 participants (64%) wore the Actical accelerometer for seven days consecutively, 23 participants (26%) for six days, seven participants (8%) for five days and two participants (2%) for four days. A previous study had reported validating the Malaysia version of the IPAQ[14], but the comparison method used was physical activity log, which may create a memory bias, as it is a subjective method similar to the IPAQ.

Concurrent validity

Overall, our results demonstrated fair correlation (ρ=0.31, $p<0.05$) between the IPAQ-M and the accelerometer-determined physical activity. We observed significant correlation for most of the activities derived from the IPAQ-M with similar activities recorded by the accelerometer. This is consistent with a previous study conducted by Craig et al.[11] (ρ=0.36) and Ekelund et al.[24] (ρ=0.34) using the Actigraph accelerometer, Wolin et al.[20] using the Actical accelerometer (ρ=0.36), and Boon et al.[25] using the Actigraph accelerometer for IPAQ-LF (ρ=0.30 to 0.32). Indeed, as the Actical accelerometer was applied for the same time period as the IPAQ-M, the participants would have referred to the same days when answering the IPAQ-M as was measured by the Actical accelerometer[24,26].

According to Lee et al.[27], a correlation of ρ=0.5 for validation studies using objective measures of PA was the minimal acceptable standard. However, their systematic review of 23 validation studies showed that correlations between the total physical activity level as measured by the IPAQ short-form and objective standards ranged from 0.09 to 0.39 with none reaching the minimal acceptable standard. Moreover, the IPAQ short form overestimated the total physical activity as measured by objective criterion methods by an average of 84%.

Reliability

We found good reliability with high correlation between the test-retest for the IPAQ-M questionnaire for vigorous, moderate, MVPA and total MET-min wk^{-1}. However, the reliability was moderate for walking, sleeping and sitting. In comparison, Craig et al.[11] reported higher reliability (ρ=0.80), which was similar to the study of Macfarlane et al.[28] using the Chinese version of the IPAQ (ρ=0.79). Reliability may be influenced by measurement errors, including participants' misunderstanding of the questions or misclassifying or misinterpreting the physical activity intensity. According to Fogelholm et al.[29], educational level can also influence the outcome of a study. Participants in rural areas generally could not estimate the amount of time spent doing an activity and tended to under-report their own activities, which may be due to their being less time conscious or due to their low educational level. Another study gave some indirect evidence that PA may be underestimated, since in the IPAQ, the duration of doing PA was limited to ten minutes or more only per session[12].

According to the *Malaysian Adult Nutrition Survey* (MANS 2003), the differing nature of the occupation of the urban and rural populations resulted in the urban population spending more time sitting and less time standing as compared to the rural population. Moreover, the urban populace spent more time working and watching television, whereas, their rural counterparts spent more time doing housework and resting[30].

The difficulty to obtain a good measure using the IPAQ-M was caused by a tendency to accumulate or round up all the time spent doing an activity throughout the day[26]. If each of the participant rounds up his activity, it will yield an over-estimation[17]; as the participants would probably have varying levels of PA throughout the week, with the participants being highly active for only a few days of the week[25]. The participants generally tended to report an average time per day

during their most active day if PA is conducted on more than one day[31].

A higher correlation value for the IPAQ was found for vigorous activity, as compared to moderate intensity activity and walking, as demonstrated by earlier studies on comparing the IPAQ data using the accelerometer monitors. Moderate intensity physical activities were likely to be incidental activities and not easily remembered in terms of the time spent compared to more structured vigorous intensity physical activities[32].

Agreement of instruments

Bland-Altman plots indicate the agreement between two instruments. We found that the datasets and standard deviation increased with duration of PA and with proportional differences. Similar to our study, Hagstromer et al.[26] reported a small mean difference (60.00 min wk^{-1}) for the time spent in moderate PA, and wide 95% limits of agreement (-15 to +17 hours wk^{-1}). These two figures are similar and likely due to participants having so little vigorous activity; hence, there was not much difference seen between the moderate PA and MVPA plots.

From our observation, participants were likely to have over-estimated their activities. There may be a tendency for participants in urban areas to over-estimate their walking time and consider walking as a moderate activity rather than a light one. However, in most instances participants' walking activity was likely not brisk or intense enough to be rated as moderate intensity PA by the Actical accelerometer. In the present study, based on participants with an average age of 54 years old, walking activity was categorized into light intensity by the objective Actical accelerometry method. The IPAQ itself does not specify the pace of walking to work, for transportation, for exercise and for leisure activity[33]. On further inspection of the outliers, it was found that all outliers were urban participants, recruited from The Malaysian Cohort study based at the UKM Medical Center, who had reported their PA with extreme values that were not reflected by their accelerometer data.

Sensitivity and specificity

The specificity was about 88% for those who met PA recommendations as determined by accelerometer and as captured by the IPAQ-M. On the other hand, sensitivity was only 43% where participants who did not meet the PA guidelines[18] were correctly classified as insufficiently active by the IPAQ-M. Although 88% of the participants were correctly classified based on the Actical and IPAQ-M, the agreement between the two techniques was only fair (κ=0.22) based on the definition of Landis and Koch[34].

Our results revealed that while the IPAQ-M provides a reasonably specific measure of PA, the sensitivity to correctly classify inactive people was limited. These findings are similar to those obtained in a study done by Ekelund et al.[24], which suggested that 77% of participants reported sufficient PA according to the ACSM/CDC guidelines by the IPAQ, whereas no more than 45% were correctly classified as insufficiently active by the IPAQ.

On the other hand, a high error rate can exist and according to Adams et al[35],socially desirable behaviour can influence PA outcome. It was reported that individuals in an exercise-conscious society often over-report[31] their PA duration by approximately 4-11 minutes a day over a seven-day period. According to Ainsworth and Levy[36], the PA outcome can be influenced by the order of the items asked in the physical activity questionnaire. Barnett et al.[37] suggested that changing the order of questions can decrease over-reporting and will increase the correlation coefficient between IPAQ and accelerometer. In the present study, we applied these suggestions and began by asking the participants about their duration of sleep followed by walking, moderate activity, vigorous activity, and finally, their sitting time. This was one approach to trigger them to provide reasonable estimation of time spent doing their physical activity.

Variability of cut-off points between instruments will influence the determination of activity categories. Similar to other validation studies, the findings were dependent on the choice of the accelerometer cut-off points; as such, we employed published algorithms that were developed by Heil et al.[22], which was suitable for adults. Masse et al.[38] also suggested that the accelerometer data processing algorithm can considerably affect the outcome variable.

Furthermore, the disagreement between the IPAQ-M and accelerometer maybe due to the under-estimation of activity levels as determined by the Actical accelerometer. Under-estimation could be influenced by the accelerometer itself, which probably unable to detect upper-body movement accurately. However, it is still the best method available and is more feasible than other advanced equipments for physical activity measurement[39,40]. Research issues such as the availability and cost of accelerometers were considered important in low-income developing countries[32]. This led to the rather small sample size focusing on Malay ethnicity only, which limits the generalizability of this study to the larger Malaysian population.

CONCLUSION

In conclusion, this study demonstrated satisfactory levels of test-retest reliability for the IPAQ-M. The validity of the IPAQ-M based on Actical accelerometer as criterion method was similar to

other self-reported PA, and can be considered as an acceptable instrument for assessing the MVPA, vigorous intensity and total physical activity among middle-aged Malay population. However, the IPAQ-M was not in agreement with the accelerometer for other categories of PA, especially for moderate-intensity and sedentary activities. Therefore, further research is recommended to study patterns of activity among the three main ethnicities in Malaysia; and if possible, a new PA questionnaire more suitable for the requirements of The Malaysian Cohort project should be developed.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

NS was responsible for study design, manuscript preparation, data collection and statistical analysis. PBK and RJ provided coordination for the study design and supervised the study. PBK, SZSZ, MIN, RJ all contributed to critically reviewing the draft manuscript for important intellectual content. All authors read and approved the final manuscript.

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REFERENCES

1. Loreto CD, Fanelli C, Lucidi P, Murdolo G, Cicco AD, Parlanti N, et al. Validation of a counselling strategy to promote the adoption and the maintenance of physical activity by type 2 Diabetics subjects. Diabetes Care. 2003; 26:2.
2. Berlin JE, Storti KL, Brach JS. Using activity monitors to measure physical activity in free-living conditions. Physical Therapy. 2006, 86:1137-45.
3. World Health Organization. Global recommendations on physical activity for health. Geneva: World Health Organization; 2010.
4. Lim SS, Carnahan E, Danaei G, Vos T, Lopez AD, Murray CJL, et al. Annual deaths attributable to physical inactivity: whither the missing 2 million? — Author's reply. The Lancet. 2013; 381:993.
5. IPH (Institute for Public Health). The Third National Health and Morbidity Survey (NHMS III) 2006. General Findings. Kuala Lumpur: Ministry of Health Malaysia; 2008.
6. Ainsworth BE. How do I measure physical activity in my patients? Questionnaires and objective methods. British Journal of Sports Medicine. 2009; 43:6-9.
7. Bergman P. The prevalence of physical activity among a random sample of the Swedish population between 18-74 years. Preventive Nutrition and Physical Activity Reports. 2004; 4:1-18.
8. Livingstone MB, Robson PJ, Wallace JM, McKinley MC. How active are we? Levels of routine physical activity in children and adults. Proceedings of the Nutrition Society. 2003; 62:681-701.
9. Bonomi G, Plasqui G, Goris AHC, Westerterp KR. Improving assessment of daily energy expenditure by identifying types of physical activity with a single accelerometer. Journal of Applied Physiology. 2009; 107:655-61.
10. Ward DS, Evenson KR, Vaughn A, Rodgers AB, Troiano RP. Accelerometer use in physical activity: best practices and research recommendations. Medicine and Science in Sports and Exercise. 2005; 37(11):S582.
11. Craig CL, Marshall A, Sjostrom M, Bauman A, Booth M, Ainsworth B, et al. International Physical Activity Questionnaire: 12 country reliability and validity. Medicine and Science in Sports and Exercise. 2003; 35:1381-95.
12. Kurtze N, Rangul V, Hustveldt B. Reliability and validity of the International Physical Activity Questionnaire in the Nord-Trondelag Health Study (HUNT) population of men. BMC Medical Research Methodology. 2008; 8:63.
13. World Health Organization. WHO Global infobase on physical activity-data from the World Health Survey 2003. Geneva: World Health Organization. 2008; Available from: http://www.who.int/infobase
14. Chu AYH, Moy FM. Reliability and Validity of the Malay International Physical Activity Questionnaire (IPAQ-M) Among a Malay Population in Malaysia. Asia Pacific Journal of Public Health. 2012; Online First: doi: 10.1177/1010539512444120
15. Rahman J, Syed Zulkifli SZ, Mohd Arman K, Nazihah AJ, Norliza I, Norkhamiwati MK, et al. Cohort profile: The Malaysian

Cohort (TMC) project: a prospective study of non-communicable diseases in a multi-ethnic population. International Journal of Epidemiology. 2014;1–9. Advance Access: doi: 10.1093/ije/dyu089

16. The International physical activity questionnaire. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ). Revised 2005. Available from: http://www.ipaq.ki.se
17. Hagstromer M. Assessment of health-enhancing physical activity at population level. Sweden: Karolinska Institute; 2007:1-50.
18. Poh BK, Nik Shanita S, Rasyedah AR, Tan SY. Key Message 3: Be physically active everyday. In: Malaysian Dietary Guidelines. Putrajaya: Ministry of Health Malaysia; 2010. p. 38-62.
19. Pfeiffer KA, Mciver KL, Dowda M, Almeida MC, Pate RR. Validation and calibration of the Actical accelerometer in preschool children. Medicine and Science in Sports and Exercise. 2006; 38(1):152-7.
20. Wolin KY, Heil DP, Askews S, Matthews CE, Bennett GG. Validation of the International Physical Activity Questionnaire-Short among blacks. Journal of Physical Activity and Health. 2008; 5(5):746-60.
21. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Medicine and Science in Sports and Exercise. 2005; 37:531-43.
22. Heil DP. Predicting activity energy expenditure using the Actical activity monitor. Research Quarterly for Exercise and Sport. 2006; 77: 64-80.
23. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986; 1:307-10.
24. Ekelund U, Sepp H, Brage S, Becker W, Jackes R, Hennings M, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. Public Health Nutrition. 2006; 9(2):258-65.
25. Boon RM, Hamlin MJ, Steel GD, Ross JJ. Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with accelerometry. British Journal of Sports Medicine. 2010; 44(10):741-6.
26. Hagstromer M, Oja P, Sjostrom M. The International Physical Activity Questionnaire (IPAQ): A study of concurrent and construct validity. Public Health Nutrition. 2006; 9(6):755-62.
27. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2011; 8:115.
28. Macfarlane DJ, Lee CC, Ho EY, Chan KL, Chan DT. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). Journal of Science and Medicine in Sport. 2007; 10(1):45-51.
29. Fogelholm M, Malmbag J, Suni J. International Physical Activity Questionnaire: Validity against fitness. Medicine and Science in Sports and Exercise 2006;, 38:753-60.
30. Poh BK, Safiah MY, Tahir A, Siti Haslinda MD, Siti Norazlin, N, Norimah, AK, et al. Physical activity pattern and energy expenditure of Malaysians adults: Findings from the Malaysian Adult Nutrition Survey (MANS). Malaysian Journal of Nutrition. 2010; 16(1):13-37.
31. Rzewnicki R, Vanden AY, de Bourdeaudhuij I. Addressing over reporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. Public Health Nutrition. 2003; 6(3):299-305.
32. Oyeyemi AL, Oyeyemi AY, Adegoke BO, Oyetoke FO, Aliyu HN, Aliyu SU, et al. The short International Physical Activity Questionnaire: Cross-cultural adaptation, validation and reliability of the Hausa language version in Nigeria. BMC Medical Research and Methodology. 2011; 11:156.
33. Dishman RK, Rooks CR, Thom NJ, Moh KW, Nigg CR. Meeting U.S. Healthy People 2010 levels of physical activity: Agreement of 2 measures across 2 years. Annals of Epidemiology. 2010; 20: 511-23.
34. Landis JR, Koch G. The measurement of observer agreement for categorical data. Biometrics. 1977; 33:159-74.
35. Adams SA, Matthews CE, Ebbeling CB, Moore CG, Cunningham JE, Fulton J, et al. The effect of social desirability and social approval on self-reports of physical activity. American Journal of Epidemiology. 2005; 161:389-98.
36. Ainsworth BE, Levy S. Assessment of health-enhancing physical activity: Methodological issues. In. Oja P, Borms J, editor. Health Enhancing Physical

Activity. Oxford: Meyer & Meyer Sport; 2004. p. 239-70.

37. Barnett J, Nigg C, de Bourdeaudhuij I, Maglione C, Maddock J. The effect of item order an physical activity estimates using the IPAQ. Californian Journal of Health Promotion. 2007; 5:23-9.
38. Masse LC, Fuemmeler BF, Anderson CB, Matthews CE, Trost SG, Catellier DJ, et al. Accelerometer data reduction: A comparison of four reduction algorithms on select outcome variables. Medicine and Science in Sports and Exercise. 2005; 37: S544-54.
39. Welk GJ. Physical activity assessments for health-related research. Champaign: Human Kinetics; 2002.
40. Esliger DW, Copeland JL, Barnes JD, Tremblay MS. Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring. Journal of Physical Activity and Health. 2005; 2(3):366-83.