

ASSOCIATIONS BETWEEN TRI-AXIAL ACCELEROMETER-DETERMINED PHYSICAL ACTIVITY AND SELF-REPORTED HEALTH-RELATED QUALITY OF LIFE OF OLDER MALAY ADULTS USING CUT-POINTS FOR VECTOR MAGNITUDE

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Abstract

Background: There are few data on the association between health-related quality of life (HRQoL) and objectively-measured physical activity (PA) in non-Westernised populations, especially the older population. Furthermore, in light of recent accelerometer models introduced in the market which assess acceleration along three axes, we theorised that a population study using cut-points based on composite vector magnitude (VM) is needed. Therefore, the aim of this study was to determine the associations between tri-axial accelerometer-determined PA and HRQoL in community-dwelling older Malay adults, using cut-points for VM. **Method:** The study design was cross-sectional, involving 146 community-dwelling older Malay adults aged 60 to 85 years old (59 men, 87 women) living in Seberang Perai Utara, Penang, Malaysia. PA data was collected using tri-axial accelerometers (Actigraph GT3X or GT3X+) worn around the hip during waking hours for 7 days. Intensities were categorised using cut-points for VM. HRQoL was measured using the Short Form 36-item Health Survey (SF-36[®]) and scored using the norm-based scoring system. Analyses included sex differences in PA variables and HRQoL and correlation (Spearman's rho) between PA and HRQoL. **Results:** Significant positive association was found between moderate PA and bodily pain, but only for men ($\rho=0.263$, $p<0.05$). Men scored higher in all eight domains of SF-36[®], but significantly higher in norm-based physical functioning ($p<0.05$) and vitality ($p<0.05$), compared to women. When scored using 0-100 scales, it was found that men scored significantly higher on four domains of SF-36[®] compared to women: PF ($p<0.05$), BP ($p<0.001$), VIT ($p<0.05$), and MH ($p<0.05$). There were no sex differences found in overall activity counts. **Conclusion:** In this sample population, tri-axial accelerometer-determined PA has minimal association to the domains of health, and men are likely to have better self-perceived health compared to women.

Keywords: Accelerometer, norm-based scoring, older adults, vector magnitude

Introduction

Health-related quality of life (HRQoL) is measured based on a person's perception of the impact that their condition or disease exert on different domains of life (i.e., physical, mental and social) and known to worsen with age (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo, Guallar-Castillón, 2011). According to the Center for Disease Control and Prevention (2012), HRQoL is defined as a broad multidimensional concept that usually includes self-reported measures related to physical, mental, emotional, and social functioning and focuses on the impact health status has on quality of life.

Leisure-time physical activity (PA) is a modifiable risk factor that could affect the HRQoL (Balboa-Castillo et al., 2011; Rejeski and Mihalko, 2001; Shibata, Oka, Nakamura, Muraoka, 2007). Although evidence on the relation between PA and HRQoL in the elderly has been established before, those studies either had used self-report measures to assess the PA (White, Wojcicki, McAuley, 2009; Brown et al., 2003; Acree et al., 2006), primarily based on clinical trials involving institutionalized elderly (Dechamps et al., 2010; Taguchi, Higaki, Inoue, Kimura, Tanaka, 2010] or examined the effect of leisure-time PA only on the mental component of HRQoL (Lee & Russell, 2003). Such studies that assess only leisure-time PA may not take in

to account activities undertaken as part of work or transport, therefore underestimating the amount of PA people engage in their daily lives. In measuring HRQoL, longitudinal study design is an advantage. To date, there has been only one longitudinal study involving community-dwelling older adults that had studied the association between PA, sedentary behavior and HRQoL (Balboa-Castillo et al., 2011). However, the study used self-report measure to assess the PA level and the sedentary behaviour, which may not accurately describe the activity patterns due to recall bias and/or its susceptibility to reporting bias by personal and social desirability (Prince et al., 2008). Other studies that had used objective measurements to assess the PA either described the association using only step counts (Yasunaga et al., 2006), using institutionalized participants (Lobo, Santos, Carvalho, Mota, 2008), or using older model of accelerometers (Actigraph 7164 or GT1M) (Fox, Stathi, McKenna, Davis, 2007, Wanderley et al., 2011), which only report acceleration along the vertical axis (VT). To the best of our knowledge, there has yet to be a study that described the association between PA and HRQoL using tri-axial accelerometer (which measures acceleration along three axes, and thus provides more information on movement) (Kelly et al., 2013) in community-dwelling older adults. PA is one of the important factors in predicting the quality of life, which varies between different cultures and countries. Thus, it is important to accurately assess and take into account the relationships within different populations in order to determine if there are differences or similarities beyond cultures and/or climates.

HRQoL is typically assessed using the Short Form 36-item Health survey (SF-36[®]; QualityMetric, Lincoln, RI). In 2007, the SF-36[®]'s scoring method was greatly simplified by the introduction of the norm-based (NB) scoring system (Ware et al., 2007). It is recommended that users based their interpretations on NB scoring system rather than the 0–100 scoring system to achieve a more meaningful comparisons across scales, and easier interpretation in relation to population norms (Ware et al., 2007). The norms were derived from the 1998 National Survey of Functional Health Status sample of the non-institutionalized adult U.S population (Ware et al., 2007). NB scoring of the SF-36[®] standardises each scale to have a mean of 50 and a standard deviation of 10. For example, anytime a scale score is below 50, it means that health status is below average, and each point is one-tenth of a standard deviation (SD). 1998 U.S general population norms were built into the scoring algorithm to allow researchers to interpret the scores correctly, without having to remember or refer to the norms for each of the eight domains of the scale. Currently, there are no normative data sources for Malaysians. However, it was suggested that the use of standard scoring (U.S derived) is preferred for comparison purposes, as results can be related to standard benchmarks, namely a mean of 50 and SD of 10 in the U.S. general population (Ware et al., 2007).

The goal of this study was to identify the associations between tri-axial accelerometer-determined PA and HRQoL in community-dwelling older Malay adults, using cut-points for VM and using NB scored SF-36[®]. The study contributes to the body of research literature by describing the association between the two variables, particularly in the older Southeast Asian population. To our knowledge, this study was also the first to assess and study the association using PA categorised by cut-points for vector magnitude (VM) in community-dwelling older adults without disability.

Methods

Older Malay adults aged from 60 to 85 years were recruited from the area of Seberang Perai Utara, Penang, Malaysia, which consists of 16 sub-districts. Potential participants were recruited by a liaison officer appointed from the 4 randomly-sampled sub-districts (using the RAND function in Microsoft Excel). Participants were visited twice at their home or were asked to gather at a public centre near their homes. During the first meeting, interested participants were briefed more about the study, covering the purpose, procedures, benefits, risks, and possible discomforts from the study. Those who agreed to participate were asked to give a written consent. A proxy in a form of family member was used to give consent on behalf of those who were illiterate. Then, each participant was given a kit containing an accelerometer (with elastic waist band), a written manual on how to correctly wear the accelerometer, and contact information in case of further questions regarding the device. After that, a demographic questionnaire was administered. The second meeting was scheduled eight days after the first to collect the accelerometer, administer the SF-36[®] and take anthropometric measurements. The inclusion criteria were as follows: 1) age 60 to 85 years old; 2) able to walk without assistance from another person; 3) of Malay ethnicity; 4) willing to wear an accelerometer for 7 consecutive days; and 5) permanent resident of Seberang Perai Utara district. Prior to

screening participants for inclusion in the study, methodological and ethical approval was obtained from the Human Research Ethics Committee, Universiti Sains Malaysia (FWA Reg. No: 00007718; IRB Reg. No: 00004494).

Measurements

- Physical activity levels

PA levels were assessed using GT3X or GT3X+ accelerometer (ActiGraph™, Pensacola, FL, USA) which previous study showed excellent reliability for total PA level; coefficients of variation [CV] 2.8%; Intraclass Correlation Coefficient [ICC] 0.99 (Aadland and Ylvisåker, 2015). Standard use of the device was explained to the participants in detail. Participants were asked to wear their accelerometers first thing in the morning. It was to be fixed on a waistband, in line with the right hip. The device was set to assess acceleration in vertical (VT), anterior-posterior (AP), and mediolateral (ML) axes, with the built-in low frequency extension (LFE) filter. The final activity count was reported as a composite vector magnitude of these three axes (VM). Compared to previous models, addition of the ability to assess mediolateral (ML) axes provided a more comprehensive assessment of body movements (Butte, Ekelund, Westerterp, 2012). The LFE filter option increased sensitivity to very low amplitude activities, effectively improving performance in the low frequency range of the device. This option is useful when measuring actigraphy data for subjects who move slowly or take very light steps, such as the elderly (GT3X+ and wGT3X+ Device Manual, 2012).

Participants were instructed to wear the accelerometer for 7 consecutive days, starting from the moment they woke up until they went to bed at night. During that time, they could remove it only for water activities such as swimming, showering, and bathing. For the GT3X model, activities were set to record at a sample rate of 1 second epochs; counts per minute (cpm) were obtained later by summing the 1 second epoch data for 60 second intervals. For the GT3X+, raw data were summed in 60 second intervals, in order to have comparable data from both monitors. All accelerometers were initialized and downloaded on the same computer (Dell Inc, Texas, United States) in order to ensure time and date matching.

For inclusion in the data analysis, each participant needed to have worn the monitor for a minimum of 10 hours per day for at least 3 days, including at least one weekend day (Davis and Fox, 2007). The timing of monitor wear was arranged to avoid periods in which an individual's activity behaviour differed from their typical 7 day routine (i.e., holidays, vacations, scheduled surgery, and sudden illness). Non-wear time was filtered from the raw data using a semi-automated algorithm in Actilife 6.5.2 software that looked for periods of ≥ 90 minutes of consecutive VM zero counts without interruptions (Peeters, van Gellecum, Ryde, Fariás, Brown, 2013). Non-wear time was defined by the time participants took off/not wearing the monitor. This non-wear time was filtered out by the software according to the manually set time. PA intensity categories used were those described by Sasaki et al. (2011) for VM; moderate=VM 2690–6166 cpm, and vigorous=VM 6167–9642 cpm. Sasaki et al. did not describe a cut-point for light intensity activity. However, Farias et al. (2013) conducted a study measuring VM cut-point for sedentary activity (VM<200 cpm). Thus, counts between VM 200 to <VM 2690 per minute were categorised as 'light intensity' category in the present study. To allow comparison with other studies in which single or bi-axial accelerometers were used, vertical axis (VT) data were analysed in addition to the composite VM data.

- Self-reported health-related quality of life

HRQoL was assessed using the previously validated Bahasa Melayu version of SF-36® (Sararaks et al., 2005). Participants were interviewed on the accelerometer collection day, face-to-face by the principal investigator or research assistants (research assistants had at least post-secondary school level education). Research assistants were trained prior to data collection using a standard manual and role-playings. The SF-36® measures HRQoL and consist of 36 items; that are aggregated into the following 8 multi-item domains: (1) physical functioning (PF) (2) bodily pain perception (BP) (3) general health (GH) (4) vitality (VIT) (5) social functioning (SF) (6) role limitations due to emotional health (EH) (7) role limitations due to physical health (PH); and (8) mental health (MH). The 8 domains, in turn, were aggregated into two summary scales that described physical and mental health: a physical component summary (PCS) and a mental component summary (MCS). In the present study, the SF-36® was scored using the NB scoring algorithm, described in the SF-36®v2 User Manual (Ware et al., 2007).

- *Domains and component summary scores*

First, each domain is scored using the 0-100 scale and standardised by deriving z-scores using means and standard deviation (SD) from the 1998 general U.S. population (Ware et al., 2007). A z-score for each domain is computed by subtracting the 1998 general U.S. population mean (obtained from the manual) from each domain score, and dividing the difference by the corresponding domain SD from the 1998 general U.S. population. Then, z-scores were converted into NB scores by multiplying them by 10 and adding 50 to the product.

The aggregate scores for PCS and MCS were computed using the physical and mental factor score coefficients from the 1990 general U.S. population obtained from the manual (Ware et al., 2007). Computation of an aggregate physical summary score consists of multiplying the z-score of each domain by its respective physical factor score coefficient and summing the eight products. Similar step is done for the mental summary score. Finally, the aggregate were converted into NB scores by multiplying them by 10 and adding 50 to the product (Ware et al., 2007).

- *Anthropometrics*

Height was measured to the nearest 0.1 cm using a portable stadiometer (SECA 217, Hamburg, Germany), and weight was measured to the nearest 0.1 kg using a body composition monitor (HBF-362, Omron Healthcare Co. Ltd., Kyoto, Japan). Body Mass Index (WHO Expert Consultation, 2004) was calculated as weight (kg)/height² (m²), and defined as: <18.5 (underweight); 18.5–24.9 (normal); 25.0–29.9 (overweight); or ≥30.0 (obese).

- *Statistical Analysis*

All statistical analyses were carried out using SPSS statistical software, version 20.0 for Windows (IBM SPSS Inc., Chicago IL, USA). Participants were included in the analysis only if they wore the accelerometer for 10 hours or more per day, for at least 3 days. Accelerometer data were filtered to only include readings from 5am to 11pm each day for standardisation purposes. Descriptive data are presented with mean and standard deviation (SD). Shapiro-Wilks test was used to test for normality. Differences between sexes were analysed using independent t-test or Mann-Whitney U test, after assumptions were met (assumptions were based on normality, dependent variable must be measured at continuous level, independent variables must consist of two independent groups, and independence of observations). Spearman's rho (r_s) correlation coefficient was used to identify the association between PA levels and each dimension of the SF-36®.

Results

One hundred and forty-six (n=146; 59 men, 87 women) community-dwelling older Malay adults (percentage and age range; 63% [60-69 years], 32% [70-79 years], and 5% [80 - 85 years]) participated in the study. The anthropometric and accelerometer data, and SF-36® domains were scored using 0-100 scales, for participants are shown in Table 1. The average BMI was (25.8 [5.0] kg/m²) in the overweight category (25<BMI<30 kg/m²), with no significant difference between the sexes. All participants were compliant, and managed to obtain an average of 6.5 (1.2) valid wear days and wear time of at least 10 hours per day (15.3 (1.3) hours).

Overall, participants spent on average of 24 minutes engaging in moderate intensity PA per day and a negligible amount of vigorous activity. Average PA in cpm for VT and VM are also shown in Table 1. There were no significant sex-differences found between the values. The SF-36®, scored using 0-100 scales found that men scored significantly higher on four domains compared to women: PF ($P=0.042$), BP ($P=0.000$), VIT ($P=0.012$), and MH ($P=0.048$) (Table 1).

Table 1: Anthropometric, accelerometer data, and SF-36® domains (scored using 0-100 scales) for participants with 10 or more hours per day, for at least 3 days of wear time.

Variable	Total (n=146) Mean (SD)	Men (n=59) Mean (SD)	Women (n=87) Mean (SD)
Age (years)	67.6 (6.4)	67.3 (5.7) (MR = 73.25)	67.8 (6.8) ^φ (MR=73.67)
Height (cm)	154.3 (8.9)	162.6 (5.7)	148.6 (5.6) ^{***}
Weight (kg)	61.1 (13.6)	66.5 (14.1)	57.5 (12.0) ^{***}
BMI (kg /m ²)	25.8 (5.0)	25.2 (4.8)	26.1 (5.2)
PA (count/min)			
VT activity per minute (counts)	226.7 (97.7)	224.9 (105.7) (MR=71.49)	227.9 (92.4) ^φ (MR=74.86)
VM activity per minute (counts)	558.5 (223.5)	555.5 (247.9) (MR=71.60)	560.5 (206.9) ^φ (MR=74.79)
Time spent in each PA intensity^a			
Time in Light Intensity PA (hours per day)	7.0 (1.9)	6.5 (1.9)	7.3 (1.9)*
Time in Moderate Intensity PA (hours per day)	0.4 (0.5)	0.5 (0.7) (MR=82.5)	0.3 (0.3) ^{*φ} (MR=67.3)
Time in Vigorous Intensity PA (hours per day)	0.0032 (0.0061)	0.0022 (0.0030) (MR=71.49)	0.0039 (0.0076) ^φ (MR=74.86)
HRQoL domains^{bφ}			
PF	73.2 (26.9)	78.3 (24.8) (MR = 82.05)	69.8 (27.8)* (MR = 67.70)
BP	80.7 (23.5)	89.7 (17.4) MR = 88.08	74.6 (25.2) ^{***} MR=63.61
GH	66.6 (18.2)	68.2 (18.5) MR=77.46	65.6 (18.0) MR=70.82
VIT	60.9 (19.0)	65.2 (19.4) MR=84.14	58.1 (18.2)* MR=66.28
SF	88.2 (17.9)	91.5 (15.5) MR=79.76	85.9 (19.1) MR=69.25
EH	81.9 (34.5)	87.0 (29.0) MR=77.36	78.5 (37.6) MR=70.89
PH	75.3 (36.6)	77.5 (36.8) MR=76.58	73.7 (36.6) MR=71.41
MH	73.5 (16.5)	77.3 (14.8) MR=81.89	70.9 (17.2)* MR=67.81

VT=vertical axis; VM=vector magnitude; PA=Physical Activity; MR=Mean Rank ^φ=Analysed using Mann-Whitney U test; the rest was analysed using independent t-test; SD=Standard deviation; *=Statistically significant between sexes (p<0.05); ***=Statistically significant between sexes (p<0.001); ^a=using VM cut-points of 200-< 2690 cpm=light, 2690–6166 cpm=moderate, 6167–9642 cpm=vigorous, ^b=scored using 0-100 scales; PF=physical functioning; BP=bodily pain perception; GH=general health; VIT=vitality; SF=social functioning; EH=role limitations due to emotional health; PH=role limitations due to physical health; and MH= mental health

Figure 1 shows the NB scores of SF-36® and the differences observed between men and women. The figure revealed that men had reported higher HRQoL than women on all domains. However, significant differences were found only on two domains: NBPF ($P=0.041$) and NBVIT ($P=0.014$). Among all the domains, NBBP perception was found to be the highest score for both sexes, albeit non-statistically significant. Referring to the summaries, individuals tend to score higher in the mental health summary compared to physical health summary (Men: MCS=53.3 (7.3) % vs. PCS=48.3 (10.1) %; Women: MCS=50.4 (8.7) % vs. PCS=46.2 (10.8) %). However, no significant differences were found between the two components, nor between the sexes.

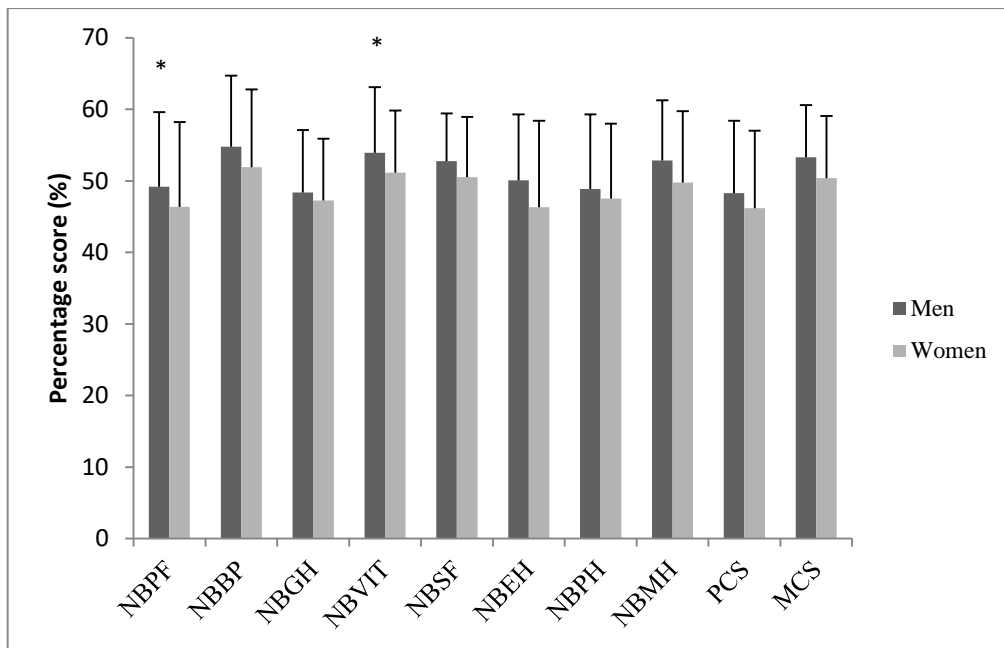


Figure 1: Percentage scores of norm-based Short Form 36-item Health survey, by sex.

NBPF=Norm-based physical functioning; NBBP=Norm-based body pain perception; NBGH=Norm-based general health; NBVIT=Norm-based vitality; NBSF=Norm-based social functioning; NBEH=Norm-based emotional health; NBPH=Norm-based physical health; NBMH=Norm-based mental health; PCS=Physical component summary; MCS=Mental component summary.

*Sex-difference: statistically significant at $p < 0.05$; analysed using Mann-Whitney U test

Table 2: Spearman’s rho correlation coefficients between each norm-based scored of SF-36® domain, component summaries, and physical activity variable.

		NBPF	NBBP	NBGH	NBVIT	NBSF	NBEH	NBPH	NBMH	PCS	MCS
PA (count/min)											
VT	Men	-0.075	0.188	-0.097	-0.127	0.070	0.117	-0.065	0.017	-0.106	0.073
	Women	-0.00	-0.014	-0.116	-0.061	-0.006	-0.029	-0.136	-0.076	-0.044	-0.042
VM	Men	-0.113	0.18	-0.077	-0.071	0.090	0.158	-0.036	0.069	-0.137	0.170
	Women	-0.084	-0.041	-0.177	0.008	-0.053	-0.112	-0.169	-0.034	-0.105	-0.039
Time spent in each PA intensity ^a											
Light	Men	-0.098	-0.080	-0.151	0.027	0.021	0.055	-0.126	0.065	-0.224	0.151
	Women	-0.086	-0.177	-0.194	-0.065	-0.107	-0.098	-0.211	-0.032	-0.182	-0.024
Moderate	Men	0.002	0.263*	0.025	-0.070	0.139	0.232	0.047	-0.017	-0.002	0.085
	Women	-0.102	-0.028	-0.109	-0.018	-0.022	-0.012	-0.099	0.006	-0.108	0.032
Vigorous	Men	-0.059	0.117	0.093	-0.153	0.256*	0.178	-0.041	-0.264*	0.058	-0.032
	Women	0.066	0.046	-0.068	-0.100	0.046	0.147	0.101	0.012	0.057	0.018

VT=Vertical axis; VM=Vector magnitude; PA=Physical activity; NBPF=Norm-based physical functioning; NBBP=Norm-based body pain perception; NBGH= Norm-based general health; NBVIT=Norm-based vitality; NBSF=Norm-based social functioning; NBEH=Norm-based emotional health; NBPH=Norm-based physical health; NBMH=Norm-based mental health; PCS=Physical component summary; MCS=Mental component summary, ^a=using VM cut-points of 200-<2690 cpm=light, 2690–6166 cpm=moderate, 6167–9642 cpm=vigorous * $P \leq 0.05$

Spearman’s correlation coefficient analyses found a weak, positive monotonic association between time spent at moderate intensity (VM) and NBBP perception, but only for men ($r_s=0.263$, $P=0.045$). Significant associations were found among NBSF, NBMH, and vigorous activity (VM; $P=0.050$ and $P=0.043$, respectively) for men. However, the amount of vigorous activity accumulated was too low to draw a valid conclusion (Table 2). There were no associations found between counts per minute as measured by VT or VM and HRQoL variables.

Discussion

The main findings of this study showed that tri-axial accelerometer-determined PA using cut-points for VM has minimal association to the NB scored SF-36[®], and men are likely to have better self-perceived health compared to women. Furthermore, for men, time spent in moderate intensity activity was associated with reduced bodily pain.

Few studies have examined the associations between HRQoL and objectively-measured PA levels in older adults (Yasunaga et al., 2006; Lobo, Santos, Carvalho, Mota, 2008; Fox et al., 2007; Wanderley et al., 2011). Evidence of the association between HRQoL and objectively-measured PA of community-dwelling older adults is limited, possibly due to the low feasibility of wearable monitors in terms of cost (wearable monitors are expensive) and logistics (Butte et al., 2012). Most research tend to use self-report method to measure the PA due to its low cost and general acceptance. However, it is not the most reliable method to assess PA in an older population (Prince et al., 2008) and many self-report measures of PA only take into account leisure time activities. With these issues in mind, the present study was conducted to gather more accurate, less-biased data on the associations between PA and HRQoL, using the new tri-axial accelerometer to measure the PA levels. Moreover, data on the association between HRQoL and PA in non-westernised populations is sparse. The present study aimed to bridge the gap of information in this area.

All the participants in this study were above 60 years of age, with 63% ranging between 60 to 69 years. There were no drop outs during the study (only 15 people were asked to wear the accelerometers again because they did not have enough valid days). All participants were from the area of Seberang Perai Utara, Penang, Malaysia and live in villages adjacent to suburbs or town (semi-rural environment). The accelerometer-determined activity counts (in VT and VM) indicate that older Malay population living in this environment exhibited a low level of PA (Table 1). This study was the first to report PA levels of older Malay adults assessed by tri-axial accelerometer and categorizing the PA intensity using cut-points for VM. Compared to previous models, the addition of the third axis, the mediolateral (ML) axis, provides a more comprehensive assessment of body movements (Butte et al., 2012).

In this study, a statistically significant association was found between moderate intensity PA and NBBP perception ($r_s=0.263$, $P=0.045$, Table 2), for men. Although significant associations were also found for NBSF and NBMH with vigorous activity for men, the amount of vigorous activity accumulated was too low to draw valid conclusions. BP questions (2 items) were meant to assess the presence of pain and limitations due to pain. A higher score means less presence of pain and limitations due to pain. A similar association between PA (assessed using biaxial accelerometer) and BP perception was also reported by Wanderley et al. (2011) ($r_s=0.258$, $P\leq 0.05$) for older adults in Portugal. However, the correlation was reported based on the total sample, rather than by sex. In our study, limited association was found between HRQoL and PA. It has been suggested that the associations between HRQoL and PA are less dramatic in older populations functioning at or above the norm for quality of life (Rejeski and Mihalko, 2001). Figure 1 shows that the mean values of HRQoL obtained by the participants in this study were close to the normative values of the 1998 U.S population (mean = 50) (Ware et al., 2007). Hence, this might explain the lack of association found between the studied parameters in the present study.

The present study found that overall, sex played a role in determining a better self-perceived health, as men tended to score higher in all of the health domains compared to women. A similar study conducted by Wanderley et al. (2011), which used 0-100 scales to score the SF-36[®], found a significant difference between the sexes in four domains: PF ($P=0.02$), VIT ($P=0.03$), MH ($P<0.01$), and GH ($P=0.03$), three of these, similar to the findings in the present study: PF ($P=0.04$), VIT ($P=0.01$), MH ($P=0.04$). It is interesting to note that when compared between each of the SF-36[®] domains (scored using 0-100 scale) to the findings of the Portuguese sample (Wanderley et al., 2011), the present study's Malay sample reported better EH, MH, BP and GH. The Portuguese sample appeared to have better scores in PF, PH, and VIT by comparison, although their SF score was similar to the present study (Wanderley et al., 2011). As previously mentioned, the same study (Wanderley et al., 2011) also found a weak, positive association between BP perception and PA (VT cpm). However, caution must be used when making comparisons between studies which utilised different models of accelerometer. Sasaki et al. (2011) found that previous models of ActiGraph accelerometer (that measure acceleration only in VT) are not comparable to the new tri-axial accelerometer (measures acceleration in $VM = \sqrt{[x^2 + y^2 + z^2]}$). Moreover, it is unclear whether studies using different scoring

systems for the SF-36® (0-100 scales) is comparable to association studies using NB scoring system. In the present study, no association was found between VT or VM total cpm and any of the NB scored domains of SF-36®.

Although there is ample evidence on the positive associations between PA and HRQoL in older adults, general consensus is still difficult to reach, mainly due to the different study designs used and different methods for measuring PA and HRQoL (Pucci, Rech, Fermino, Reis, 2012). For example, a cross-sectional study by Lobo et al. (2008) showed that higher accelerometer-determined PA in older adults was associated with better PF, PH, VIT and less BP on the SF-36®. Similarly, a study using self-report measurement of PA involving 112 older adults also found that higher levels of PA was associated with better score on various domains of the SF-36® (Acree et al., 2006). However, in a 12-month study involving older adults identifying the effect of PA (in a form of multi-component supervised exercise program) on HRQoL (using other type of measurements than SF-36®), no significant effect was found (Taguchi et al., 2010). Questions arise whether there is a specific mode or intensity of PA that would positively affect HRQoL in general. Further studies, possibly with standardised measurements, and a larger sample size are needed in order to identify associations, particularly longitudinally, between different modes of PA and HRQoL. Moreover, country-specific normative data would also be an advantage, so that parallel analyses using international and Malaysian-derived NB scoring could be performed to determine if conclusions would otherwise vary.

Limitations of this study include the following: a low number of older-old people (≥ 80 years old); a disproportionate number of women compared to men; and the inability of the accelerometers to detect certain movement patterns, such as upper body movements during activities like heavy carrying. The accelerometers used are also limited in their ability to detect non-ambulatory activities such as cycling (Chen and Basset, 2005). Six participants reported using a bicycle during the day, but only intermittently. In addition, although the cross-sectional design of the study was ideal for its primary aim of identifying the relationship between variables, this design may have partially limited the findings, in that cause-and-effect relationships could not be determined. Despite the limitation, this study has several strengths, particularly the use of tri-axial accelerometer to assess the PA levels, using cut-points for VM, and identifying the association using the NB scored SF-36®.

Conclusion

This research concluded that tri-axial accelerometer-determined PA showed minimal association to the NB scored domains of SF-36® in this sample of older Malay adults. Men were more likely to have better self-perceived health compared to women and for men, time spent in moderate intensity activity was associated with reduced bodily pain.

Highlights/Practical Considerations

- In this sample population, accelerometer-determined PA showed minimal association to the NB scored domains of SF-36®.
- Men are more likely to have better self-perceived health than women.
- Standardised measurements are needed in order to determine associations, particularly longitudinally, between different modes and/or intensities of PA and HRQoL in the population.
- Country-specific normative data would also be an advantage, so that parallel analyses using international and locally-derived NB scoring may be done to determine if conclusions would otherwise vary.

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