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Individual scaling of accelerometry to preferred walking speed in the assessment of physical activity in older adults

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Abstract

Background. Walking forms a large portion of physical activity (PA) of older adults. We assessed free-living PA using acceleration corresponding to preferred walking speed as a relative cut-point, and studied how it relates to age. We compared the relative cut-point to a common absolute cut-point of moderate-to-vigorous PA (MVPA).

Methods. 444 community-dwelling adults aged 75, 80 and 85 wore an accelerometer on the thigh during a PA surveillance period and a modified six-minute walking test (6MWT) at preferred speed. Each individual's mean acceleration (g) during the 6MWT was used as a cut-point for relative PA. Acceleration corresponding to three metabolic equivalents (METs) was used as the cut-point for absolute MVPA.

Results. When using the acceleration of preferred walking speed as a cut-point, 62 (SD 82) minutes a week of relative PA was detected, compared to 228 (163) minutes of absolute MVPA. For 96 % of the participants, the acceleration generated by their preferred walking speed exceeded the common absolute cut-point for MVPA. Absolute MVPA was lower in the older age groups, and 6MWT speed explained 22 % of its variation ($p<0.001$), whereas relative PA was independent of walking speed and age.

Conclusions. Preferred walking speed was a significant contributor to absolute MVPA, and those who walked the slowest accumulated the least MVPA. Assessing relative PA using the intensity of preferred walking speed as a cut-point eliminated the dependency of PA on age and walking speed, and may be a feasible scaling option to evaluate relative PA among older people.

Keywords: exercise intensity, physical performance, accelerometer, cut-point

1. Introduction

Walking is a recommended and commonly practiced mode of physical activity (PA) among adults of all ages (1,2). Walking speed captures a spectrum of life-style, health and aging changes and has been termed "the sixth vital sign" (3). People typically prefer to walk at a speed that optimizes their energy consumption relative to the travelled distance (4). The resulting preferred walking speed remains rather constant throughout adult life until the age of 65 (5). After that the preferred walking speed slows down with an increasing rate after the age of 80. Yet, the slower preferred walking speed of older people requires similar energetic cost as the faster preferred walking speed of younger adults (5). In relative terms, walking is physically more intensive for older adults than for younger people due to their age-related decrease in physical performance (6,7). Since walking forms a large portion of daily PA of older adults, the correct classification of walking at the preferred pace as either light or moderate intensity PA is essential for accurate assessment of moderate-to-vigorous PA (MVPA).

Accelerometry has become a popular method for assessing the amount of MVPA in large-scale studies due to its feasibility and putative objectivity (8). The computation of MVPA from the raw accelerometry signal requires several important decisions that will affect the result (9). One of them is the selection of the lower cut-point for moderate intensity PA. An absolute cut-point corresponding to three metabolic equivalents (METs) has been recommended by expert panels (10,11) and extensively adopted for accelerometry-based measurement of MVPA in different population groups, including older adults (12–14). However, recently it has been recommended that relative intensity rather than absolute intensity should be used to assess PA intensity in older adults due to their lower average physical performance (15). The importance of assessing relative intensity is underlined by the fact that the absolute and relative cut-points for MVPA will be the same only for individuals whose cardiorespiratory fitness equals about seven METs (11). Only minority of older men and even smaller proportion of older women reach this level during maximal exercise (16). It has been shown that absolute and relative cut-points for MVPA result in very different estimations of MVPA among people of different ages (17).

Assessing how strenuous daily PA is relative to a person's physical capacity requires additional measurement of physical performance for individualization of the cut-points. Preferred walking speed assessed over a predetermined distance (e.g. 400 m) or time (e.g. 6 minutes) may provide a meaningful physiological context for specifying the individualized cut-point for relative PA to be analyzed from the raw accelerometry signal. Preferred walking speed is associated with key determinants of physical performance: peak oxygen uptake (18,19) and muscle strength (20). Tests of preferred walking speed are fairly simple to perform even in large scale studies, because they require only minimal equipment (21). Analyzing long-term accelerometry data relative to the intensity of preferred walking speed obtained in a standardized walking test may provide new information on the complex interplay between physical performance, PA and health (22). When performance testing is not possible, it would still be important to know, whether the acceleration and perceived exertion induced by walking at the preferred speed is first, counted as MVPA in the selected study group and second, perceived as moderately hard in relative terms.

The main purpose of this study was to examine the relative PA determined as the time spent at or above the acceleration generated by the preferred walking speed in three age cohorts: 75-, 80- and 85-year-old people. For comparison, we calculated absolute MVPA using the universally accepted moderate intensity cut-point of three METs. Furthermore, the intensity of preferred walking speed was compared to the absolute three MET cut-point in older adults.

2. Methods

2.1 Study design and setting

The data for the present cross-sectional analyses are from a population-based study of three age cohorts: 75, 80, and 85 years (23,24). The sample was drawn from the Population Information System administered by the Population Register Centre (http://vrk.fi/en) to include everyone living independently nearby the city center of Jyväskylä, in Central Finland. The ethical committee of the Central Finland Health Care District provided an ethical statement on the AGNES study protocol on August 23, 2017. Participants were required to provide a written informed consent at the beginning of the data collection. Participants were allowed to withdraw their consent at any time during the study or for any individual part of the study. The cross-sectional data collection was performed during 2017-2018, and consisted of a phone interview, a face-to-face interview, a postal questionnaire, one-week PA surveillance and physical assessments in the research center, which in all took two to four weeks to complete. The exact protocol for recruitment and assessments has been presented previously (24).

2.2 Participants

For the home interview and the postal questionnaire we included everyone who was willing to participate and able to communicate and thus, provided research data (N=1021). Those who additionally were willing to participate in the physical assessments in the research center (n=910) were asked to wear an accelerometer for seven to ten days. Additional exclusion criterion for PA surveillance was a known allergy to adhesive since accelerometers were taped on skin. Furthermore, as the accelerometers were not fully water-resistant, we had to exclude participants who were swimming, bathing or taking a sauna multiple times per week. Eventually, 495 participants agreed to wear an accelerometer on the thigh. Our non-respondent analysis showed, that those who participated in the PA surveillance (i.e. wore an accelerometer either on the thigh or on the chest or both, n=496) did not differ from those who only participated in the research center assessments (n=415) in terms of sex, self-rated health, or walking difficulty over 500 m, but had higher self-reported PA and higher walking speed (24).

Out of the 495 participants who gave their consent to wear the thigh accelerometer, data for a total of 11 participants were excluded from the surveillance analyses due to either loss of monitor (n=2), technical error (n=1), or data availability for less than 3 full days (n=8), thus providing surveillance data for 484 participants. Finally, 40 participants were not included because of missing walking test data, which was required for the calculation of relative PA, thus leaving 444 participants for the analyses.

2.3 Physical activity surveillance

A thigh-worn accelerometer (13-bit ±16 g, UKK RM42, UKK Terveyspalvelut Oy, Tampere, Finland) (25,26) was attached by a research assistant to the anterior aspect of the mid-thigh of the dominant leg (defined as primarily, the take-off leg, secondarily, the kicking leg and thirdly, the leg on the side of dominant hand) (27). The accelerometer was taped on using an adhesive film for covering to make it water resistant and to minimize non-wear. The participants were asked to wear the monitor for a minimum of seven consecutive days. A research assistant visited the participants at their homes once in the middle of the surveillance period to replace the adhesive. Finally, the monitor was removed at the research center at the end of the physical assessments. The participants were asked to keep a simple log on their exercise sessions, non-wear periods and reasons for removing the device during the surveillance, had that happened.

2.4 Assessments in the research center

Preferred walking speed in a six-minute walking test (6MWT). A modified 6MWT was performed at preferred pace while wearing the accelerometer (18). Participants were allowed to use a cane if necessary. The test was performed in an indoor corridor. Traffic cones were placed at both ends of the course 19.66 m apart, and a tape indicated the bend with a 0.30 meter radius, resulting in a 40-meter lap. The laps were manually calculated during the test and in uncertain cases, visually confirmed from the accelerometer data. Total distance walked by the participants in six minutes was measured together with rating of perceived physical exertion (RPE) using 6-20 scale (28). Of the participants with sufficient PA surveillance data, 15 did not perform the walking test, 2 discontinued and 5 paused during the test. Furthermore, accelerometry data of the walking test was not available for 18 participants due to non-wear (n=6) or lost data (n=12).

Descriptive and anthropometric variables. Physical assessments in the research center included standard objective anthropometric measurements of weight and height. Body mass index (BMI) was calculated as weight in kilograms divided by height squared in meters (kg/m^2). Total number of chronic conditions was calculated from a physician-diagnosed list of conditions, which were self-reported during the home interview. The list included 34 items and an open-ended question about any other physician diagnosed chronic conditions (29). Age and sex of the participants were derived from the Population Information System in the context of recruitment. Age was used to divide the participants into three separate age cohorts (75, 80 and 85) to compare the amount of PA at different age. PA is likely to be higher in men compared to women (30), and therefore, the results were stratified by sex. Lower-extremity physical performance was assessed in the participant's home using the Short Physical Performance Battery (SPPB) (31). The battery comprises tests on standing balance, walking speed over a 3-m distance, and the ability to rise from a chair. A sum score was calculated (range 0–12), where higher scores indicate better performance.

2.5 Accelerometry analysis

High-pass filtered vector magnitude (HPFVM, in g) was calculated from the raw accelerometry records in five-second non-overlapping epochs after applying auto calibration following the procedure described by White and colleagues (32). Briefly, all recorded accelerometry files were fed into our autocalibration Java implementation (source code https://github.com/tjrantal/accelerometer-auto-calibration commit f8ca5bb) (33). Based on experimentation we deviated from the procedure described by van Hees and colleagues (33) and did not include weights in the optimization procedure, because weights caused over fitting in cases where one of the axes had not reached values close to one g while stationary. Our implementation utilized Levenberg-Marquardt algorithm in the iterative minimization of the error function.

$$\sqrt{{X_i'}^2 + {Y_i'}^2 + {Z_i'}^2} - 1 = \varepsilon$$

$$X_i' = X_i * s_x + o_x \,;\; Y_i' = Y_i * s_y + o_y \,; Z_i' = Z_i * s_z + o_z$$

In the formula, X, Y and Z are the measured accelerations, prime (‘) indicates the calibrated value, and subscript i indicates the index of a data point (e.g. X_i’ is the calibrated acceleration of the sensor X-axis for data point i); s = calibration coefficient; o = calibration constant for offset; subscript x, y and z are axes on which the calibration coefficients are applied. The calibration coefficients and constants were iteratively optimized.

The calibrations for each particular accelerometer were pooled, sorted based on the vector magnitude of the calibration coefficients, and the middle-most (rounded down if even number of calibrations were obtained) calibration was utilized for all files measured with the accelerometer.

The 6MWT was identified from the laboratory testing day accelerometer recording using the accelerometer time stamps in one second increments and a record of when the test had started.

The walking test was identified as consecutive epochs of mean amplitude deviation between 0.035 g and 1.2 g lasting at least 4 minutes within 20 minutes of the recorded arrival. The mean HPFVM of the five-second epochs of the 6MWT was recorded as the outcome. Continuous walking throughout the test was required for the analysis of mean 6MWT acceleration.

For PA surveillance analyses the whole series of 5-second epochs were split into full 24-hour days from mid-night to mid-night. Three values were produced as outcomes for each day:

1) *Daily average acceleration*: the mean HPFVM of all of the recorded 5 s epochs (34),

2) *Absolute MVPA*: the number of epochs at or above the acceleration that corresponds to three METs based on White and colleagues' linear equation for thigh-measured HPFVM (32). For this, we required two activity-caused METs plus one from resting metabolism, which resulted in HPFVM $\geq$ 0.24 g.

3) *Relative PA*: the number of epochs above or equal to the mean acceleration calculated during the laboratory-measured 6MWT.

The mean of the days scaled for a full week was used as the outcome for each participant, and the number of epochs for absolute and relative PA were divided by 12 (12 epochs/min * 5 s/epoch = 60 s/min = 1 min) to produce the results in minutes. We only included days with complete data without non-wear, which was visually verified from the data. Only participants with at least three successfully recorded days and continuous acceleration data from the walking test were included in the subsequent analyses.

2.6 Statistical analyses

Group values are means followed by standard deviations (SD, in parenthesis) or frequency of occurrence. Distributions and variances were tested for skewness and heteroscedasticity, respectively. Square root (absolute MVPA) or logarithm transformation (daily average acceleration, relative PA and SPPB score) was used to correct the skewness of distribution. The differences between the age cohorts and the sexes were tested using univariate analysis of variance (UNIANOVA) or Pearson's chi-squared test. If a significant association with age was found, Bonferroni post hoc test was performed to test the differences between consecutive age cohorts. In case of a significant age*sex interaction, the post hoc test was conducted separately for men and women. Correlations between different measures of PA and walking test were tested with Pearson correlation coefficients or the equivalent non-parametric Spearman correlation coefficient. Determinants of absolute MVPA and relative PA were further investigated using linear regression analyses. The coefficient of determination was calculated separately for preferred walking speed (model 1) and age (model 2) and for both combined adjusted further with total number of chronic conditions and sex (model 3).

3. Results

Characteristics of the participants are presented in Table 1. The age cohorts were clearly separate as the difference between the youngest and oldest person within each age group was 1.6, 1.9 and 1.5 years for 75-, 80- and 85-year-old people, respectively. Majority (59.5 %) of the participants were women. Women had similar total number of chronic conditions and SPPB score compared to men. BMI was 27.2 (4.2) on average with 22 % of participants classified as obese (BMI ≥ 30 kg/m^2). Accelerometer wear-time was 6.6 (0.7) days overall and similar in all age groups.

The amount of absolute MVPA based on the three-MET cut-point was not different between the 75- and 80-year-old people, but was lower in the 85-year-old people (Table 1). Based on relative PA defined as the activity at or above the acceleration corresponding to the preferred walking speed in the 6MWT, the present group of 75-year-old people spent 63 (71) minutes per week above the cut-point. For the 80- and 85-year-old people, the amount of relative PA was 61 (95) and 61 (89) minutes per week, respectively. Relative PA was not significantly different between the age groups (p=0.27).

Daily average acceleration, computed as the mean acceleration of all the recorded epochs of the full 24-hour days, was not significantly different in the 80-year-old people compared to the 75-year-old people (mean 0.025 (SD 0.008) vs. 0.025 (0.008) g, p=1.00), but was lower in the 85-year-old people (0.022 (0.008) g, p=0.005) compared to 80-year-old people (Fig. 1A). Average values of the PA variables stratified for sex are presented in Table 1.

Preferred walking speed in the 6MWT was significantly faster (p=0.006) in the 75-year-old people compared to the 80-year-old, who walked faster (p<0.001) than the 85-year-old people (Table 1). There was also a significant age effect in the corresponding mean acceleration during 6MWT (p=0.001). Older participants perceived the exertion during the walking test harder than younger participants (p<0.001). Individuals reported RPE values between 6 and 17 in the youngest cohort and between 7 and 19 in the two oldest cohorts. A significant age*sex interaction was observed in RPE indicating that the difference between the age cohorts occurred at younger age (between 75 and 80 years) in men compared to women (between 80 and 85 years). Results stratified by age group and sex for walking speed, acceleration and RPE in the 6MWT are presented in Table 1.

The generally used cut-points for moderate (three METs) and vigorous (six METs) PA were equivalent to acceleration of 0.24 g and 0.63 g, respectively, based on the previously published equation (32). In the 6MWT, 4 % of participants walked below the 0.24 g. Majority i.e. 91 % walked between 0.24 and 0.63 g, and 5 % above 0.63 g (Fig. 2A). The equivalent percentiles in walking speed represent a cut-point of 0.8 m/s for moderate and 1.5 m/s for vigorous activity. There was a positive correlation (r = 0.77, p<0.001) between walking speed and acceleration during 6MWT (Fig. 2B).

Absolute MVPA was associated with all walking test parameters (Table 2). The association was positive with objective measures of walking intensity (6MWT speed and acceleration), and negative with subjective intensity (RPE). Relative PA correlated negatively with 6MWT acceleration and RPE but was not significantly associated with 6MWT walking speed. 6MWT speed was positively correlated with daily average acceleration ($r = 0.57$, $p<0.001$, Fig. 1B, Table 2).

Regression analysis showed that 6MWT speed explained 22 % of the variation in absolute MVPA ($p<0.001$, Table 3, Model 1). The coefficient of determination was only increased by 1 % when age, total number of chronic conditions and sex were included (Model 3). Relative PA was not significantly explained by 6MWT speed ($R^2 = 0.000$, Model 1) or age ($R^2 = -0.002$, Model 2). The only significant contributor to relative PA was the total number of chronic conditions ($\beta = -0.13$, $p=0.01$, Model 3).

4 Discussion

The absolute cut-point of three METs for moderate intensity is intended as a generalized guideline for health enhancing PA (15). It may be unsuitable for population groups that deviate from the general average, such as young adults for whom three METs only represents light intensity on average (11) or older adults who may have low maximum MET (7) and slow walking speed (5). The present results showed that accelerometry-assessed MVPA based on the absolute three MET cut-point was significantly determined by preferred walking speed in a 6MWT, which indicates that MVPA is not a pure measure of physical behavior. The correlations between the absolute MVPA, preferred walking speed and RPE imply that those whose preferred walking speed was the slowest and who perceived the effort the hardest accrued less MVPA. In contrast, relative PA that was individually scaled to preferred walking speed was independent on age and walking speed. The present novel measure of relative PA is directly interpretable as the amount of accelerometry-detected movement that equals or exceeds the intensity of preferred walking speed.

Preferred walking speed is an important indicator of physical performance in older adults (19). In the present study, preferred walking speed was significantly lower in the older age groups, especially at the age of 85 years. Similarly, the amount of absolute MVPA was lower in the 85-year-old people compared to the 80- and 75-year-old people. The diversity of cut-points in the literature complicate the comparison of MVPA between studies. Therefore, we also calculated a cut-point independent variable named average acceleration which has been recently suggested (35). Average acceleration has potential for improving coherence between studies. However, it is dependent on physical performance similarly to absolute MVPA as indicated by the positive association to preferred walking speed in the present study. Average acceleration also varies between accelerometer wear locations, whereas the present scaling method takes the wear location automatically into account. Majority of scientific literature indicates that PA declines in aging (12,36). While the conclusion is justified in the light of the absolute measures of PA, the decline may be mainly due to the simultaneous decline of physical performance and PA intensity rather than physical behavior. As a support for this notion, we did not observe any difference in the relative PA between the age groups of 75, 80 and 85 when the acceleration corresponding to preferred walking speed was used as a cut-point. Furthermore, the relative PA was not determined by walking speed or sex which supports the independence of the novel relative measure of PA from physical performance.

There are several methods for estimating relative intensity of PA. One that is often recommended for older adults is the subjective RPE (37). The RPE scale is a practical instrument for exercise testing in the laboratory and for supervised exercise sessions but not a user-friendly tool for a long-term PA surveillance. Heart rate has been used for long-term monitoring of PA in older adults, excluding participants with diagnosed arrhythmias (38). Due to the increasing occurrence of undiagnosed arrhythmias, such as atrial fibrillation with age (39), the validity of heart rate as the measure of PA intensity in older adults requires further study. Our approach was to utilize the intensity of preferred walking speed rather than maximum intensity, which is more difficult to measure reliably and safely. The relative cut-point based on the acceleration generated by the preferred walking speed was higher on average (0.43 g) compared to the absolute cut-point of three METs (0.24 g). Therefore, the amount of relative PA was much lower than the amount of absolute MVPA. This is to be expected in people with normal physical performance (17,38), whereas in more frail older adults, relative PA may be higher than absolute MVPA (38). The low amount of PA exceeding the intensity of the preferred walking speed may also indicate that the participants walked somewhat faster in the laboratory compared to free-living, which has been previously shown to happen in an 8-feet (2.44-meter) test (40).

The acceleration generated by the preferred walking speed in a 6MWT was higher than the common MVPA cut-point of three METs in a majority (96 %) of the present community-dwelling older adults. Perceived exertion during 6MWT was on average somewhat hard corresponding to moderate intensity according to the RPE classification (11). The present finding on the large proportion of older adults whose preferred walking intensity was within the universally adopted cut-points may be misleadingly positive. The present proportion of older adults not reaching the cut-point (4 %) was considerably smaller compared to that of sedentary participants at risk for mobility disability of whom 25 % did not reach even the lowest of the cut-point intensities investigated (22). Studies with inclusion criteria similar to the present study have reported average preferred walking speed of about 1.2 m/s with a range from 0.5 to 2 m/s (5,41). Comparison to the present average speed of 1.2 m/s and to the three MET cut-point corresponding to 0.8 m/s implies that our results could be applied to other similar population groups. Yet, the most important notions are the large individual variation in the preferred walking speed across studies and the small amount of activity that older people accumulated beyond the intensity of preferred walking speed. Exceeding the usual stimuli in terms of PA intensity is the rationale for the whole concept of cut-point based assessment of PA. The overload principle of physical training states that, exercise below a threshold intensity will not challenge the body enough to produce improvements in physical performance, and that the threshold intensity is dependent on initial level of fitness (11).

The main limitation of our study was that the current sample of 75-, 80- and 85-year-old adults was somewhat more physically active than each age cohort on average. Our earlier analysis showed that those who participated in the PA surveillance had somewhat higher walking speed and self-reported PA than those who participated in the parts of the study requiring less commitment (24). Although our sample was quite large, we were probably unable to recruit individuals who had poorest health and functioning and thus, the proportion of older adults not reaching the current three-MET cut-point during the 6MWT would probably be larger in the whole population. We also had to exclude seven more participants who either discontinued or paused during the test, to be able to compute a meaningful average acceleration value for 6MWT. For future studies, it may be worthwhile to consider using a shorter walking test or computing median acceleration (22). The advantage of the 6MWT is that it is also a widely used test for physical performance for older adults with published technical standards (42). Our approach was similar to Gremeaux et al. (18) and deviated from the standards in one important way: we did not instruct the participants to cover as much distance as possible in six minutes. Instead, we instructed the participants to walk at a steady pace at their preferred walking speed to promote wider inclusion of participants and continuous walking throughout the test. Finally, when comparing our results to other studies, it is important to note the short epoch length of five seconds that we used in the free-living accelerometry analysis to include even the shortest bouts of activity. A short epoch length produces higher amount of PA compared to a longer epoch length (43).

In conclusion, using a relative cut-point defined as the acceleration corresponding to preferred walking speed may eliminate the dependency of PA assessment on age and physical performance, which is characteristic of MVPA based on any fixed cut-point. The present older adults accumulated very little activity at or above the acceleration corresponding to the preferred walking speed. Interestingly, individuals with faster preferred walking speed did not accumulate more activity at or beyond the present relative cut-point than individuals with slower speed. Yet, the intensity of PA should exceed that of preferred walking speed in order to result in sufficient stimuli for performance adaptations. The universally adopted three MET cut-point for MVPA (equivalent to 0.24 g of thigh-based HPFVM) was inclusive of the acceleration generated by preferred walking speed in the present 75-, 80- and 85-year old people. Further studies are needed to explore the significance of the novel measure of individually scaled PA in the future development of physical performance and function of older adults.

Conflict of interest

The authors have no conflicts of interest to declare.

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Captions for Tables and Illustrations

Table 1. Characteristics of participants, and results from the six-minute walking test and physical activity surveillance in each age group as mean and standard deviation (SD). *Note.* BMI, body mass index (kg/m^2); Chronic conditions, total number of individual chronic conditions; SPPB, short physical performance battery score (0-12); absolute MVPA, moderate-to-vigorous physical activity using acceleration corresponding to three METs as a cut-point; relative PA, physical activity using acceleration corresponding to preferred walking speed as a cut-point; 6MWT, six-minute walking test; RPE, Rating of perceived exertion on the Borg scale 6-20; [a]Pearson's chi-squared test; *p<0.05, **p<0.01, ***p<0.001 of Bonferroni post hoc analyses for consecutive age cohorts.

Table 2. Correlation coefficients between physical activity and walking test parameters. *Note.* 6MWT, six-minute walking test; RPE, rating of perceived exertion; absolute MVPA, moderate-to-vigorous physical activity using acceleration corresponding to three METs as a cut-point; relative PA, physical activity using acceleration corresponding to preferred walking speed as a cut-point; [a] Pearson or [b] Spearman correlation coefficients, ***p<0.001.

Table 3. Linear regression models for absolute MVPA and relative PA according to preferred walking speed, age, total number of chronic conditions and sex. *Note.* absolute MVPA, moderate-to-vigorous physical activity using acceleration corresponding to three METs as a cut-point; relative PA, physical activity using acceleration corresponding to preferred walking speed as a cut-point; R^2 = Coefficient of determination.

Figure 1. (A) Daily average acceleration computed as the mean of high-pass filtered vector magnitude throughout the day. The bars from left to right are for males and females, respectively. (B) Correlation between walking speed in the six-minute walking test and daily

average acceleration. Circles indicate 75-year-old, squares 80-year-old and triangles 85-year-old people.

Figure 2. (A) Distribution of the average acceleration during a six-minute walking test (6MWT). The figure shows the proportion of participants who walked in the moderate intensity range defined as an intensity between 3 and 6 metabolic equivalents (METs) corresponding to acceleration of 0.24 and 0.63 g, respectively. The proportions of the remaining participants who walked below or above moderate intensity are also shown. (B) Correlation between preferred walking speed in the 6MWT and the corresponding 6MWT acceleration in the age groups of 75, 80 and 85.

Table 1.

	Women				Men				p (sex*age)	p (age)	p (sex)
	75 (n=141)	80 (n=77)	85 (n=46)	All (n=264)	75 (n=86)	80 (n=61)	85 (n=33)	All (n=180)			
Age (years)	75.4 (0.3)	79.6 (0.4) ***	84.5 (0.4) ***	78.2 (3.5)	75.4 (0.4)	79.6 (0.4) ***	84.5 (0.4) ***	78.5 (3.4)	0.94	<0.001	0.35
Height (m)	1.59 (0.05)	1.59 (0.05)	1.56 (0.05) ***	1.59 (0.05)	1.73 (0.06)	1.72 (0.06)	1.68 (0.06) ***	1.72 (0.06)	0.68	<0.001	<0.001
Weight (kg)	70.2 (12.1)	68.5 (11.0)	68.5 (9.9)	69.4 (11.4)	80.4 (12.5)	79.3 (11.3)	75.2 (11.8)	79.1 (12.1)	0.44	0.08	<0.001
BMI (kg/m^2)	27.6 (4.5)	27.2 (4.2)	28.3 (4.4)	27.6 (4.4)	26.8 (4.1)	26.7 (3.6)	26.5 (3.6)	26.7 (3.8)	0.55	0.76	0.02

Chronic conditions (count)	3.1 (1.9)	3.3 (2.0)	3.8 (1.9) *	3.3 (2.0)	2.7 (1.9)	3.0 (1.8)	4.0 (1.9) *	3.0 (1.9)	0.44	<0.001	0.50
SPPB (0-12)	10.6 (1.5)	10.6 (1.5)	9.4 (2.3) ***	10.4 (1.7)	10.9 (1.4)	10.7 (1.7)	9.8 (1.9) ***	10.6 (1.7)	0.87	<0.001	0.16
Wear time (days)	6.7 (0.7)	6.7 (0.6)	6.5 (0.9)	6.7 (0.7)	6.6 (0.8)	6.6 (0.8)	6.7 (0.5)	6.6 (0.7)	0.20	0.79	0.97
Absolute MVPA (min)	233 (171)	219 (148)	149 (145) *	215 (163)	273 (162)	229 (165)	219 (153) *	248 (162)	0.25	0.001	0.005
Relative PA (min)	66 (74)	58 (74)	48 (54)	60 (71)	59 (66)	64 (117)	78 (120)	64 (96)	0.85	0.27	0.84
Daily average acceleration (g)	0.024 (0.008)	0.024 (0.008)	0.020 (0.007) **	0.023 (0.008)	0.028 (0.009)	0.026 (0.008)	0.024 (0.008) **	0.026 (0.008)	0.64	<0.001	<0.001
6MWT speed (m/s)	1.20 (0.19)	1.14 (0.20) **	0.99 (0.23) ***	1.14 (0.21)	1.27 (0.21)	1.19 (0.17) **	1.11 (0.25) ***	1.22 (0.22)	0.58	<0.001	<0.001

6MWT acceleration (g)	0.42 (0.10)	0.42 (0.10)	0.38 (0.13) *	0.41 (0.11)	0.49 (0.12)	0.45 (0.11)	0.43 (0.15) *	0.47 (0.12)	0.24	0.001	<0.001
RPE (6-20)	12.1 (2.4)	12.4 (2.2)	13.9 (2.2) **	12.5 (2.4)	11.4 (2.3)	12.4 (2.1) *	12.2 (2.8)	11.9 (2.4)	0.03	<0.001	0.001
Walking aid, cane (%)	2.1	6.5	4.3	3.8	0	0	3.0	0.6	–	0.28 [a]	0.03 [a]

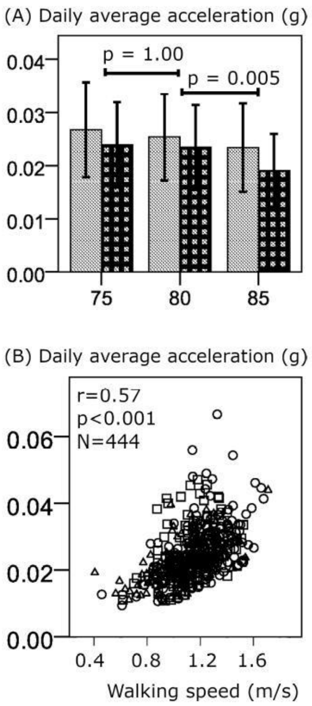
Table 2.

	6MWT speed[a] (km/h)	**6MWT acceleration[a] (g)**	**RPE after 6MWT[b] (6–20)**	**Relative PA[a] (mins)**	**Absolute MVPA[a] (mins)**
Daily average acceleration (g)	0.57***	0.49***	-0.33***	0.42***	0.92***
Absolute MVPA (mins)	0.55***	0.49***	-0.32***	0.48***	
Relative PA (mins)	-0.08	-0.30***	-0.17***		

Table 3.

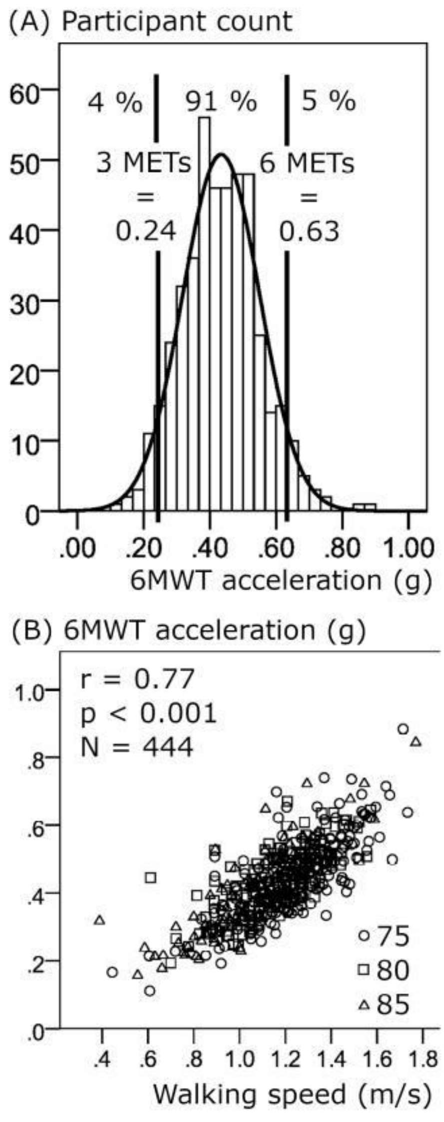
	Model 1 (walking speed)			Model 2 (age)			Model 3 (adjusted)		
	R^2	Beta	P	R^2	Beta	P	R^2	Beta	P
Absolute MVPA	0.22		<0.001	0.02		0.001	0.23		<0.001
Walking speed (m/s)		0.47	<0.001		–	–		0.42	<0.001
Age (years)		–	–		-0.16	0.001		0.002	0.97
Chronic conditions (count)		–	–		–	–		-0.14	0.001
Sex (1=men,0=women)		–	–		–	–		0.03	0.54
Relative PA	0.000		0.35	-0.002		0.73	0.01		0.08
Walking speed (m/s)		-0.04	0.35		–	–		-0.10	0.06
Age (years)		–	–		-0.02	0.73		-0.03	0.59
Chronic conditions (count)		–	–		–	–		-0.13	0.01
Sex (1=men,0=women)		–	–		–	–		0.03	0.48

Figure 1



(A) Daily average acceleration (g)
p = 1.00
p = 0.005
0.04
0.03
0.02
0.01
0.00
75
80
85
(B) Daily average acceleration (g)
r=0.57
p<0.001
N=444
0.06
0.04
0.02
0.00
0.4
0.8
1.2
1.6
Walking speed (m/s)

Figure 2



(A) Participant count
4 %
91 %
5 %
3 METs = 0.24
6 METs = 0.63
60
50
40
30
20
10
0
.00 .20 .40 .60 .80 1.00
6MWT acceleration (g)
(B) 6MWT acceleration (g)
r = 0.77
p < 0.001
N = 444
1.0
.8
.6
.4
.2
.0
75
80
85
.4 .6 .8 1.0 1.2 1.4 1.6 1.8
Walking speed (m/s)