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This is an **author produced version** of a paper published in:

Journal of Sports Sciences Volume 37.10 (2019): 1080-1087

**DOI:** <https://doi.org/10.1080/02640414.2018.1544185>

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**Criterion-related Validity of Self-report Walking Time from the EPIC Questionnaire  
in older Adults.**

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**Short title:** Validity of the self-reported walking time in older adults

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## Abstract

Tools for measuring walking time make use of objective and subjective methods. One subjective approach is to administer physical activity questionnaires (PAQ), mainly because they are inexpensive and easy to give to large groups. The European Prospective Investigation into Cancer and Nutrition (EPIC) study has a brief PAQ (EPIC-PAQ) and includes one question referencing walking time. The objective of this study was to assess the validity of the question about time spent walking included in the EPIC-PAQ.

The sample included 200 older adults (113 women). To assess daily walking time, participants responded to the EPIC-PAQ in an interview and wore a portable gait analysis system and physical activity monitor for 48 consecutive hours in free-living condition.

Results indicated that the mean of bias between the EPIC-PAQ and objective measurement was -64.6 min/day. Also, the correlation was low compared to an objective measurement ( $\rho=0.196$ ) and was positively correlated with the time spent at speeds below 2.5 mph but the correlation was low (slow walking  $\rho=0.154$  and pace walking  $\rho=0.163$ ).

The EPIC-PAQ shows low correlations with the objective measurement of walking time, that suggests it may be inaccurate and affecting the estimate of the EPIC-PAQ's PA energy expenditure in this age group.

Keywords: physical activity questionnaires, gait analysis, activity monitor

## Introduction

There is strong evidence that regular physical activity (PA) has numerous health benefits in older adults, such as lower rates of coronary heart disease, hypertension, stroke, diabetes, and higher levels of cardiorespiratory and muscular fitness (1). Walking is one of the most common types of PA (2) and less time spent walking is associated with higher mortality in older people (3). It is also the single most commonly reported PA in public health surveys (4).

Tools for measuring walking time make use of objective and subjective methods. One subjective approach is to administer PA questionnaires (PAQ), and they are used frequently in epidemiological studies (5), mainly because they are inexpensive and easy to give to large groups (6). However, few PAQ showed acceptable-to-good results in reliability and validity when compared to objective measurements of PA (7). Despite many of them containing walking-time questions, their criterion-related validity is unclear (8).

One example is the European Prospective Investigation into Cancer and Nutrition (EPIC) study, which has a brief PAQ (EPIC-PAQ) referencing occupational, household, and recreational activities over the past year (9). One of the questions specifically refers to the amount of time spent walking. Although the results of this questionnaire show high estimates of global PA (10) in people from 60 to 65 years old (11), no study has investigated the criterion-related validity of the question using accelerometers or activity monitors as gold standard measures.

At present, activity monitors provide a great opportunity to increase and refine our knowledge about PA (12) because they are able to independently monitor the time spent, intensity and velocity of patterns such as walking. As a consequence, the validity of some questionnaires may improve from using the same kind of data, unlike other studies where

walking time from questionnaires has been compared with steps and counts in light, moderate or vigorous PA or locomotive or non-locomotive (8,13,14). The objective of our study was to assess the validity of the question about time spent walking included in the EPIC-PAQ by comparing its responses to the results of an activity monitor in older adults.

## Methods

### *Participants*

The sample included the first 200 older adults (113 women) recruited from wellness and senior centers in the Community of Madrid, Spain, to take part in the IMPACT65+ study. This cross-sectional study was designed to examine the relationship between objectively-measured PA and indicators of frailty, quality of life and health in apparently well-functioning, community-dwelling adults aged 65 and older.

Participants were informed about the objectives of the study and their informed consent in writing was obtained. Ethical permission for the study was granted by the Autonomous University of Madrid's Research Ethics Committee.

### *Self-report walking time*

To assess daily walking time, participants responded to the EPIC-PAQ in an interview. The EPIC-PAQ includes the following question about the amount of time in hours per week spent walking in summer and in winter: "In a typical week over the past 12 months, how many hours did you spend walking including walking to work, going shopping and for fun?" (9). With this data we obtained the total daily walking time (average of winter and summer) from the EPIC-PAQ using the following equation:

$$\text{Total walking from EPIC-PAQ (min/day)} = \frac{(\text{walking time in summer} + \text{walking time in winter})/60}{7 \text{ days}}$$

The same equation was used to calculate daily walking time in summer and winter separately.

### *Objectively-measured walking time*

Participants wore the Intelligent Device for Energy Expenditure and Activity (IDEEA monitor) for 48 consecutive hours in free-living condition. The IDEEA monitor

(MiniSun, Fresno, CA) is a small microcomputer-based portable PA measurement device worn on the belt (main recorder microprocessor, 70 x 44 x 18 mm, 59 g) and both ankles (two subrecorders, 16 x 14 x 4 mm, 2 g each). It has five movement sensors which are attached to the skin with medical tape (one to the sternum, two to the thighs and two proximal to the head of the fourth metatarsal), according to manufacturer's recommendation. The sensors send information about posture and activities to the subrecorders and main recorder over wireless (thigh sensors) and solid cables (thighs and sternum sensors). The IDEEA monitor was initialized by individually calibrating it following the software instructions. This activity monitor can recognize up to 40 different types of activity and it has been proven valid in early studies (15,16). The IDEEA monitor has very high walking-detection rates (99.7%) (15).

Furthermore, two groups (winter, participants who wore the IDEEA monitor from October to March, and summer, participants who wore the monitor from April to July and September) were formed to compare data from the EPIC-PAQ. The walking speeds registered by the IDEEA monitor were classified into three categories following the PA compendium (17): very slow (<2 mph), slow pace (2 to 2.5 mph), moderate pace (>2.5 mph).

The minimum wear time for a valid day was set at 20 hours.

#### *Other variables*

Other data was also obtained from participants. Height and weight were measured and body mass index (BMI) was calculated as  $\text{weight/height}^2$  (kg/m<sup>2</sup>). Information on education and health was collected. The latter was self-reported by participants and divided into two categories: no chronic condition and  $\geq 1$  chronic condition (diabetes, coronary heart disease, stroke, asthma, rheumatism, cancer, hip fracture, Parkinson's disease, and

Alzheimer's or other dementia). Likewise, participants were categorized into no frailty and pre-frailty or frailty based on the five Fried frailty criteria (18).

### *Statistical analyses*

Participant characteristics are presented as mean  $\pm$  standard deviation (SD) and percentage. Sex differences were analyzed using independent samples t-tests. For validity analysis, the Spearman rho correlation coefficient between walking time from the EPIC-PAQ and the IDEEA monitor was calculated. The magnitude of the association was interpreted using Cohen's criteria: insubstantial ( $<0.10$ ), small ( $0.10$  to  $0.30$ ), moderate ( $0.30$  to  $0.50$ ) and large ( $>0.50$ ) (19). The strength of agreement and bias between methods was assessed using the Bland–Altman plot. To complement the assessment of agreement and given that the EPIC-PAQ contains both winter and summer data, the Kaplan-Meier method (20) was used to construct survival-agreement curves. This method shows the absolute differences in the x-axis and the proportion of cases with differences that are at least the observed difference in the y-axis between objectively measured walking time registered by the IDEEA monitor (differentiating between those who complete the study in the summer and those who complete the study in the winter) and walking time in the EPIC-PAQ. To compare curves, the log rank test was used. In addition, Cohen's weighted kappa was used to evaluate the agreement between methods specifically by tertiles, quartiles and quintiles. The agreement was classified into four categories: fair ( $0.21$ - $0.40$ ) moderate ( $0.41$ - $0.60$ ), substantial ( $0.61$ - $0.80$ ) and almost perfect ( $>0.81$ ) (21,22). Statistical analysis was performed using STATA version 12.0 (Stata Corp, College Station, TX, USA). The statistical significance was set at  $p<0.05$ .



## Results

Table 1 shows the descriptive characteristics of the study sample. The mean age was  $71.6 \pm 4.6$  years. A total of 30% of participants had secondary studies or higher and about 70% reported completing elementary school or less. Half of participants reported at least one or more chronic condition and around 55% had pre-frailty or frailty.

A total of 168 participants had valid data in walking time from the EPIC-PAQ and the IDEEA monitor. The percentage of participants with two valid days was 86.3%. Total daily walking time reported from the EPIC-PAQ was  $61.5 \pm 48.5$  min. The men reported more walking time than the women, showing statistically significant difference in the total walking time (14.2 min,  $p=0.046$ ) and in the self-reported times for summer (16.3 min,  $p=0.033$ ). In contrast, daily walking time from the IDEEA monitor was more than double ( $125.2 \pm 52.8$  min) and showed that men spent more time walking in winter and less in summer than women though unlike the EPIC-PAQ these differences were only statistically significant in winter (28.2 min,  $p=0.035$ ).

Table 2 provides criterion validity between walking time from the IDEEA monitor and walking time from the EPIC-PAQ in the total sample and by gender. In the total sample, statistically significant correlations were found between total walking time from the IDEEA monitor and walking time reported from the EPIC-PAQ for winter ( $r=0.206$ ,  $p=0.007$ ), summer ( $r=0.185$ ,  $p=0.017$ ) and the average of both ( $r=0.196$ ,  $p=0.011$ ). In men a significant correlation was found in winter ( $r=0.248$ ,  $p=0.034$ ) and there was no significant correlation for women.

For those who wore the IDEEA monitor in winter, in the total sample there was a moderate significant correlation between the self-report walking time in the EPIC-PAQ for winter ( $r=0.410$ ,  $p<0.001$ ), summer ( $r=0.393$ ,  $p=0.001$ ) and the average of both ( $r=0.402$ ,

$p=0.001$ ) and no significant correlation for those who wore the IDEEA monitor in the summer. However, when analyses were broken down by gender, we observed that correlation with the EPIC-PAQ was moderate in those women who wore the IDEEA monitor in winter but was not significant in summer, while for men, the correlation was insignificant in both winter and summer (Table 2).

When the relationship between several walking speeds from the IDEEA monitor and the walking time reported in the EPIC-PAQ was examined, it was found that very slow walking and slow pace walking were positively correlated with the walking time in the EPIC-PAQ for winter ( $r=0.190$ ,  $p=0.014$  and  $r=0.163$ ,  $p=0.035$  in very slow and slow pace walking respectively) and the average between winter and summer (slow walking  $r=0.154$ ,  $p=0.046$  and pace walking  $r=0.163$ ,  $p=0.035$ ). Analysis by gender showed that slow walking from the IDEEA monitor was positively correlated to the time reported in the EPIC-PAQ for winter ( $r=0.318$ ,  $p=0.006$ ) and the average between winter and summer ( $r=0.242$ ,  $p=0.039$ ) for men (Table 3).

For total time spent walking, the mean of bias between the total walking time from the IDEEA monitor and the EPIC-PAQ was -64.6 min/day (95% limits of agreement= -198.8 to 69.7 min/day; Figure 1a). After evaluating the agreement between the total time walking from the IDEEA monitor and in the EPIC-PAQ separately we found that the mean of bias was higher in summer (-67.1 min/day in summer and -57.1 min/day in winter; Figure 1b and Figure 1c, respectively). These differences were also shown in the Kaplan-Meier survival-agreement curves (Figure 2) where the absolute difference between walking time from the IDEEA monitor and the EPIC-PAQ for summer (gray curve) is always above the absolute difference between the walking time from the IDEEA monitor and the EPIC-

PAQ for winter (black curve). The analysis of the log rank test showed statistical significant differences between curves ( $p=0.028$ ).

The percentage of perfect agreement between the IDEEA monitor and walking time in the EPIC-PAQ was 41.4, 34.9 and 25.4% and the weighted kappa was a poor 0.12, 0.13 and 0.13 for tertiles, quartiles and quintiles respectively. For perfect to acceptable agreement, the weighted kappa was also a poor 0.15, 0.15 and 0.13 while the percentage of agreement increased 62.4, 63.9 and 66.1 for tertiles, quartiles and quintiles respectively (Figure 3).

## Discussion

The purpose of this study was to assess the validity of the question about time spent walking included in the EPIC-PAQ using an objective measurement in older adults. Results indicated that this question's correlation is low compared to an objective measurement. In those participants who responded to the EPIC-PAQ in winter the correlation was moderate, although when broken down by gender it was moderate in women and weak in men. Walking time as reported in the EPIC-PAQ was positively correlated with the time spent at speeds below 2.5 mph but the correlation was low.

Data from this research is in line with previous validation studies which observed low to moderate correlation between self-report walking and the accelerometer criterion standard. In the study of adults by van der Ploeg, et al., the Spearman correlation between self-report walking time from the International Physical Activity Questionnaire (IPAQ) and an accelerometer data was fair to moderate (0.18-0.39) (8). In adults  $\geq 65$ , Cerin, et al. showed fair to moderate correlation between self-report walking time and several intensities from the accelerometer (light  $r=0.36$ , moderate  $r=0.11$  and moderate to vigorous  $r=0.11$ ) in the validation of the Chinese version of the IPAQ (14). In adults aged  $\geq 85$  years, Oguma, et al. used a modified version of the Zutphen PAQ and found low to moderate correlation between self-report walking and the steps, physical activity index and moderate-vigorous physical activity index from the accelerometer (0.18, 0.34 and 0.36 respectively) (13).

Conceptually, the EPIC-PAQ only refers to walking time outdoors, as the other PAQ carried out in older adults and that include questions about walking [e.g., CHAMP (23), PASE (24) or Minnesota LTFAQ (25)]. As a result, older adults may be self-reporting less walking time thereby influencing the estimate of the amount of daily PA. In our study,

we observed that the EPIC-PAQ underestimated the total time that older adults spent walking (one hour/day on average). The differences could be explained by walking time recorded by the IDEEA monitor because it can identify all daily walking time, including the brief periods at low speeds that individuals spend walking indoors and outdoors. This suggests that for older adults it may be difficult to contextualize casual walking or walking at low speed as PA (12), and therefore, they might not associate the self-report walking question with all the time spent walking (especially light walking) that they might do during the day (e.g., walking around the house, daily shopping, errands, walking the dog or picking up their grandchildren).

Besides the underestimated total walking time in the EPIC-PAQ, our results also showed weak correlations of several walking speeds from the IDEEA monitor, especially over 2.5 mph. This could produce inaccuracies related to the EPIC-PAQ estimate of energy expenditure (EE) owing to a possible overestimate of the intensity and walking speed associated with the activity and in this age group. It is generally accepted that the EPIC-PAQ's assigned intensity for walking is 3.0 METs (Metabolic Equivalent Task) for adults (9), which are associated with walking speeds of  $\geq 2.5$  mph (17). Nevertheless Barnett, et al. showed that the walking speed which corresponds to the intensity of three METs in older adults is less than 2.5 mph (26). In our results, we observed that the EPIC-PAQ's walking time had no correlation with walking time at a moderate pace ( $\geq 2.5$  mph). If we take into account that walking is a major contributor to physical activity in this age group (27), both the underestimated walking time and its overestimated intensity could affect the EE estimated by the EPIC-PAQ for this activity, rendering it inaccurate when measuring daily EE in older adults.

We also identified differences by gender and season in the association between objective and subjective measurements of walking time. Our findings suggest that walking time assessed by the EPIC-PAQ was better correlated with IDEEA walking time in women than in men. This could be due to the fact that in older adults, the time spent on light PA is greater and less variable than the time spent on moderate to vigorous PA (17,28). This fact has been observed specifically in women, showing lower moderate to vigorous PA and higher light PA than in men (26). Since in our study much of the walking time was light PA (under three METs) this could explain the stronger correlation than in men.

Regarding the seasonal effect, the EPIC-PAQ walking time correlation with IDEEA monitor walking time was higher in winter than in summer. It seems that PA levels may change with the season in older adults (29); so daily walking time may vary (30). Previous studies showed that PA levels in older people are much higher in summer than in winter because in the winter there is less daylight, temperatures are generally lower and less inviting and it is more likely to rain (31). All these factors may contribute to concentrating older adults' walking time in a short and scheduled periods. These periods might be easier for older adults to remember and their answers might be more accurate. We suggest that a more valid answer might be obtained in older adults if the EPIC-PAQ is administered in winter, especially if the EPIC-PAQ is given in countries where there are more extreme changes in weather and the contrast in daylight hours between the winter and the summer is greater.

Our research highlights the weak correlation between subjective and objective measurements of walking time, suggesting some limitations already described in other studies and which indicate the difficulty of self-measurement to assess much of older adults' daily PA, especially light PA (12, 32). Since older adults are more likely to engage

in these kinds of activities and that walking is one of the common sources of PA in this age group (2), much of their daily PA may go unrecognized or underestimated when measured by self-reporting methods. Given that the assessment of PA in many of the studies (including epidemiological ones) use self-report walking time, researchers should be careful in their interpretation and generalization of the results obtained by using this methodology.

The study has some limitations. The sample was not representative and the study was carried out in a country (Spain, southern Europe) where the weather conditions vary widely between seasons so our results could not be extended to all populations. We also use the self-report walking time from the EPIC-PAQ where only walking time is taken into account so our findings cannot be generalized to other self-report questionnaires that contain this information and others, such as different types of walking (e.g., walking indoors and outdoors, walking for leisure and for exercise, etc.) and walking speeds. For our analysis, we classified walking speeds from the IDEEA monitor into three categories so additional slower speed categories might be needed to check and correlate with objective measurements. However, lower speeds may be less reliably recorded and more difficult to monitor using accelerometers. One of the strong points of this research lies in its use of microcomputer-based portable PA devices, which reliably detect walking. No previous study has specifically investigated the walking time measured objectively in comparison to subjective measurements.

## **Conclusion**

Our study showed that the walking question from the EPIC-PAQ underestimates an important part of the time that older adults spend walking. It also showed a low correlation with the objective measurement of walking. It suggests that self-report walking time may be inaccurate, affecting the estimate of the EPIC-PAQ's PA energy expenditure in this age group. Similarly, many studies which use self-report methods may offer insufficient assessment of walking time, so data from these studies should be interpreted with care. Given the importance of walking time in the daily PA of older adults, and the extensive use of self-report methods in research, more investigation on the validity of this method is needed.



**Disclosure**

All authors have no conflict of interest and nothing to disclose.

**Funding**

This research was supported by XXXXX I+D+i (XXXXXX), XXXXX (2015-20), and XXXXX (XXXXX).

(XXXXX) and (XXXXX) receive a predoctoral scholarship from XXXXX University (XXXXX2016).

Table 1. Descriptive characteristics of the study sample

	Total	Men	Women
<i>n</i>	168	73	95
Age (years)	71.6±4.6	72.5±6.1	71.0±5.3
Younger older adults <sup>a</sup>	47.6	41.2	58.7
Elderly older adults <sup>a</sup>	52.4	45.4	54.5
Education level (%)			
Primary studies or lower	70.0	39.0	61.0
Secondary studies or higher	30.0	54.0	46.0
Health status (%)			
No chronic condition	50.6	45.9	54.1
>1 Chronic condition	49.4	41.0	59.04
Frailty syndrome <sup>b</sup> (%)			
No frailty	45.1	45.2	54.8
Pre-frailty or frailty	54.9	43.8	56.2
Body mass index (kg/m <sup>2</sup> )	29.2±4.6	28.5±3.4	29.7±5.4
Walking time from the EPIC-PAQ questionnaire (min/day)			
Average summer+winter	61.5±48.5	68.6±61.3	54.4±34.9*
Winter	59.5±43.9	65.4±52.9	53.6±34.9
Summer	63.5±54.5	71.7±71.1	55.4±35.9*
Walking time from the IDEEA monitor (min/day)			
Total sample	125.2±52.8	128.1±55.6	123.04±50.8
Winter <sup>c</sup>	<i>n</i> =69 119.7±56.8	<i>n</i> =19 140.1±68.2	<i>n</i> =50 111.9±50.6*
Summer <sup>d</sup>	<i>n</i> =99 129.1±49.8	<i>n</i> =54 123.7±50.5	<i>n</i> =45 135.3±48.7

Data are given in mean ± standard deviation. <sup>a</sup> sex-specific. <sup>b</sup> According to Fried frailty criteria (Fried et al., 2001). <sup>c</sup> Participants who wore the IDEEA monitor from October to March. <sup>d</sup> Participants who wore the IDEEA monitor from April to July and September. \* Denote statistically significant between sexes ( $p<0.05$ )

Table 2. Spearman's rho correlation between the question about walking time from the EPIC-PAQ and the total walking measured by the IDEEA monitor

Walking from the IDEEA monitor	Walking from the EPIC-PAQ						
	Average winter- summer			Winter		Summer	
	<i>n</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
All							
Total	168	<b>0.196</b>	<b>0.011</b>	<b>0.206</b>	<b>0.007</b>	<b>0.185</b>	<b>0.017</b>
Winter <sup>a</sup>	69	<b>0.402</b>	<b>0.001</b>	<b>0.410</b>	<b>&lt;0.001</b>	<b>0.393</b>	<b>0.001</b>
Summer <sup>b</sup>	99	0.082	0.421	0.089	0.383	0.071	0.485
Men							
Total	73	0.181	0.125	<b>0.248</b>	<b>0.034</b>	0.161	0.174
Winter <sup>a</sup>	19	0.200	0.411	0.257	0.287	0.200	0.411
Summer <sup>b</sup>	54	0.161	0.246	0.229	0.096	0.146	0.291
Women							
Total	95	0.082	0.421	0.089	0.383	0.071	0.485
Winter <sup>a</sup>	50	<b>0.443</b>	<b>0.001</b>	<b>0.444</b>	<b>0.001</b>	<b>0.445</b>	<b>0.001</b>
Summer <sup>b</sup>	45	0.067	0.662	0.065	0.669	0.026	0.715

<sup>a</sup> Participants who wore the IDEEA monitor from October to March. <sup>b</sup> Participants who wore the IDEEA monitor from April to July and September. Data in bold indicates statistical significance  $p < 0.05$

Table 3. Spearman's rho correlation between the walking time from the EPIC-PAQ and the time spend at different walking speed measured by the IDEEA monitor

Walking from the IDEEA-monitor			Walking from the EPIC-PAQ						
			Average winter-summer		Winter		Summer		
	<i>n</i>	<i>Mean min/day±SD</i>	<i>Average min/day±SD</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
All	168								
<2 mph		74.17±29.73		<b>0.154</b>	<b>0.046</b>	<b>0.190</b>	<b>0.014</b>	0.135	0.082
2 to 2.5 mph		25.84±18.49	61.5±48.5	<b>0.163</b>	<b>0.035</b>	<b>0.163</b>	<b>0.035</b>	0.150	0.052
>2.5 mph		25.20±32.38		0.080	0.300	0.064	0.413	0.089	0.250
Men	73								
<2 mph		69.50±26.10		<b>0.242</b>	<b>0.039</b>	<b>0.318</b>	<b>0.006</b>	0.210	0.074
2 to 2.5 mph		25.79±19.65	68.6±61.3	0.103	0.338	0.121	0.308	0.088	0.461
>2.5 mph		32.74±38.40		-0.075	0.529	-0.053	0.656	-0.066	0.579
Women	95								
<2 mph		77.76±31.95		0.122	0.240	0.131	0.207	0.117	0.258
2 to 2.5 mph		25.88±17.66	54.4±34.9	0.193	0.061	0.177	0.087	0.184	0.074
>2.5 mph		19.40±25.59*		0.164	0.113	0.138	0.184	0.167	0.105

\*Indicates statistical differences between sexes  $p<0.05$ . Data in bold denotes statistical significance  $p<0.05$ .





