Pedometer-Determined Physical Activity and Its Comparison With the International Physical Activity Questionnaire in a Sample of Belgian Adults

Katrien De Cocker, Greet Cardon, and Ilse De Bourdeaudhuij

Pedometer-determined physical activity (PA) levels in Belgian adults were provided and compared to PA scores reported in the International Physical Activity Questionnaire (IPAQ). The representative sample (N = 1,239) of the Belgian population took on average 9,655 (4,526) steps/day. According to pedometer indices 58.4% were insufficiently active. Steps/day differed significantly between gender (F = 5.0, p = .026), age groups (F = 3.3, p = .01), employment status (F = 6.2, p = .013), and days of monitoring (F = 7.4, p = .007). Steps/day were negatively correlated to the time spent sitting and positively to PA at work, in transport, and in leisure time (p < .001). Steps data can discriminate between PA levels reported in the IPAQ. Belgian population pedometer-determined PA levels are higher than those reported in samples of the United States; however, there is a wide distribution of ambulatory behavior.

Key words: physical activity level, step counter, steps/day, survey

Physical inactivity is a major public health concern in modern society. Regular physical activity (PA) is needed to gain physiological and psychological health benefits and to reduce the risk for a number of adverse health outcomes including cardiovascular diseases, obesity, hypertension, diabetes mellitus, and all-cause mortality. International guidelines recommend that adults accumulate 30 min or more of moderate to vigorous PA on most, preferably all, days of the week (American College of Sports Medicine [ACSM], 2000; U.S. Department of Health and Human Services [US-DHHS], 1996). To evaluate whether this recommendation is being reached, constant timing and summing of scattered bouts of activity during the day may be needed. This requires constant attention, which is impractical, to assess PA on the individual and population levels. Recently, an alternative guideline has been introduced, which is more practical than the 30 minutes/day recommendation and does not require constant tracking of at least moderate-intensity activity time during the day. This guideline recommends that accomplishing 10,000 steps/day improves health (Hatano, 1993, 1997; Wilde, Sidman, & Corbin, 2001). Consequently, with the continued promotion of the 10,000 steps/day recommendation, pedometers have become popular as a monitoring and motivational tool. Pedometers objectively assess ambulatory activities throughout the day in the form of step counts; several studies have shown that they provide a valid and accurate measure of activities in free-living conditions (Bassett et al., 1996; Welk et al., 2000). Moreover, pedometers are simple to use and, in comparison
to accelerometers, are relatively inexpensive both in terms of cost per unit (pedometers: approximately US $20–50; accelerometers: approximately US $150–500) and data processing.

Even though pedometers have limitations such as variability between different brands and are insensitive to nonambulatory activities (i.e. cycling, swimming), pedometer-determined PA data are useful in PA studies in free-living populations (Basset et al. 1996). The international comparison of population levels of PA can be less complex and the problem of incomparable data, due to different questionnaires in different languages and with different interpretations, is also resolved. Additionally, the recently introduced pedometer indices for public health by Tudor-Locke and Bassett (2004) offer a greater value to pedometer use and pedometer-based data. In the past, several studies have been conducted using a pedometer to collect PA data in specific groups of the population in free-living conditions (Basset, Schneider, & Huntington, 2004; Chan, Spangler, Valcour, & Tudor-Locke, 2003). However, information on population-based step counts is still sparse and has been collected only in a limited number of countries.

In 1989, Sequeira, Rickenbach, Wietlisbach, Tullen and Schutz (1995) showed that the pedometer was useful in a large, free-living population survey. In this Swiss population, the average number of steps/day differed between age groups: 11,900 for the 25–34-year-old men and 6,700 for the 65–74-year-old men, and 9,300 for the youngest women and 7,300 for the oldest women.

In the United States, Wyatt, Peters, Reed, Barry and Hill (2005) also used pedometers to collect information in a first-ever statewide survey of walking. The data collected in 2002 revealed that the average adult in Colorado took about 6,800 steps/day. In 2001, Tudor-Locke, Ham et al. (2004) collected descriptive epidemiology data of pedometer-determined PA in adults in South Carolina. Participants wore a pedometer for seven consecutive days during winter and took on average about 6,000 steps/day. The latter two studies showed different step counts, which varied according to demographic characteristics. Males accumulated more steps/day than females, and white participants took more steps than non-whites (Tudor-Locke, Ham et al., 2004). In both studies, steps/day declined with increasing age, and participants with a college degree, high income, and normal weight took more steps/day than participants with respectively a high school degree or less, low income, and obesity (Tudor-Locke, Ham et al., 2004; Wyatt et al., 2005).

According to Miller and Brown (2004), the average number of steps taken each day in a sample of working Australian adults was about 8,900. Workers in managerial and professional occupations reported lower weekday step counts (7,883) than technical (10,731) and blue collar (11,784) workers. Earlier, Brown, Ringuet, and Trost (2002) found that young mothers accumulated around 9,800 steps/day. The step level of the Western Australian adult population was 9,695 steps/day (Mc Cormack, Milligan, Giles-Corti, & Clarkson, 2002).

In the literature, no recent pedometer-based data are available for European countries. Since Europe has different environmental characteristics (e.g. greater availability of bike lanes) and socioeconomic characteristics (e.g. governmental regulation of health care) than other parts of the world, pedometer-determined PA in Europe may also differ from pedometer-determined PA levels reported in other continents. Therefore, the first purpose of the present pilot study was to provide and evaluate pedometer-determined PA levels in a sample of Belgian adults. Comparisons in pedometer-determined PA were made between sexes, age groups, employment status, and days of monitoring.

Because pedometers are easy to use, more objective than surveys, and reasonably priced compared to accelerometers, they appear to be appropriate tools to assess worldwide PA levels. Sequeira et al. (1995) already proposed the use of pedometers as an objective index of PA. However, it remains unclear whether pedometer-determined PA data provide sufficient information to adequately describe differences in diverse domains of PA. For that reason, the second purpose was to compare pedometer-determined PA with reported work-, transport-, home-, and leisure time-related PA levels from the International Physical Activity Questionnaire (IPAQ).

Method

Procedures

A random sample of 5,000 names and addresses (1,000 names for each age group: 25–35 years old, 36–45 years old, 46–55 years old, 56–65 years old, and 66–75 years old) were obtained from the public record office. Of this sample, 3,340 telephone numbers were found and 2,751 persons were able to be reached by telephone within a maximum of four attempts. They were asked to complete the IPAQ long telephone version and to self-monitor pedometer-determined PA for seven consecutive days. About 48% (N= 1,322) of them agreed to take part. One hundred and four 66–75-year-old participants, who were not prepared to complete the pedometer protocol, completed only the IPAQ. To reach the participants without a telephone number and to increase the study sample, a written explanation of the study with the self-administered IPAQ long form was
randomly sent to another 1,316 participants (386 letters went out to the 25–35-year-old age group; 263 letters were sent to the 36–45-year-olds; 232 to 46–55-year-olds; 248 to 56–65-year-olds; and 187 to 66–75-year-olds). The response rate to this written recruitment was 19.6% (n = 258). As a result a total of 1,084 participants completed the IPAQ form with 1,580 of this number consenting to wear the pedometer. Of this sample, 1,239 participants completed the pedometer protocol.

Based on the methods of Tudor-Locke, Ham et al. (2004), a package was mailed to all participants who agreed to self-monitor pedometer-determined PA. The package included a pedometer, a written informed consent form, a protocol describing how and when to use the pedometer, an activity log to keep daily activity records, and a preaddressed and stamped envelope for return mailing. All participants were instructed to attach the pedometer to their waistband or belt during waking hours. They were asked to reset their pedometer to zero at the beginning of each day. Participants were asked to carry on their usual activities and to remove the pedometer only while bathing, showering, or swimming and to complete the activity log at the end of each day.

All participants gave their informed consent, and the study was approved by the Ethical Committee of Ghent University. Data collection took place between March and May 2005. Up to three attempts were made to contact participants who did not return the pedometer and/or the activity log after one month. Eventually 445 participants who did not complete the pedometer protocol were excluded from the present dataset.

**Participants**

In total, 1,239 25–75-year-old adults in Flanders, Belgium, completed the present pedometer study. Participants completed the IPAQ and self-monitored pedometer-determined PA for seven consecutive days. The sample consisted of 604 men (age $M = 49.2$ years, $SD = 13.7$) and 635 women (age $M = 48.1$ years, $SD = 13.5$). The mean age of the total sample was 48.6 ($SD = 13.6$) years: 252 participants were 25–35 years old ($SD = 20.3$%), 269 were 36–45 years old ($SD = 21.7$%), 287 were 46–55 years old ($SD = 23.1$%), 248 were 56–65 years old ($SD = 20$%), and 183 were 66–75 years old ($SD = 14.8$%). This group finished school at the mean age of 19.5 ($SD = 3.4$) years (highest level of education: high school degree), and 19.4% had a low level of education (finished school at the maximum age of 16, having no high school degree). About 68% of all participants had a job, and 87% reported having a good-to-excellent state of health. All participants reported pedometer data on at least three days. Following recommendations by Tudor-Locke, Burkett et al. (2005), no participants were excluded from the dataset. Demographic variables such as gender, age, and level of education of the present sample were comparable to those of the overall Belgian adult population (respectively 51.2% women: $x^2 = 0.001$, $p = 0.973$; 21.2% 25–35-year-olds, 24.5% 36–45-year-olds, 22.3% 46–55-year-olds, 17.3% 56–65-year-olds, and 14.8% 66–75-year-olds: $x^2 = 1.69$, $p = 0.997$; 21.5% low level of education: $x^2 = 0.96$, $p = 0.327$; see Scientific Institute of Public Health, [AQ: Date?]).

Comparisons were made between participants who provided step count information (N = 1,239) and participants who did not complete the pedometer protocol (n = 445). Participants who had a job (odds ratio: 1.59, $p = 0.002$) were more likely to complete the pedometer protocol than unemployed participants. Analyses on gender, age, years of education, state of health, time spent sitting, and total amount of PA showed no significant differences.

**Instruments**

**Pedometers.** The pedometer used in the present study was the Yamax Digiwalker SW-200 (Yamax, Tokyo, Japan). According to the literature, the Yamax pedometer is accurate and reliable for counting steps (Crouter, Schneider, Karabulut & Bassett, 2003; Schneider, Crouter, Lukajic & Bassett, 2003).

**Activity Log.** Participants were requested to keep daily activity records for the seven consecutive days they wore the pedometer. They were asked to record the date, the day-end steps taken, and activities such as walking, soccer, fitness activities. The structure of the activity log was based on the activity log used by Tudor-Locke, Lind, Reis, Ainsworth, & Macera (2003). Next to the date and day-end steps taken, participants were asked to complete some closed-ended questions (yes or no), namely “Did you remove your pedometer during the day?” “Were you sick or injured?” “Did you participate in any sports or PA?” If the pedometer was removed, the reason and the amount of time of the removal were asked. Participants who engaged in any sports or physical activities were asked to record the type and duration of the exercise (e.g., 20 min spent walking). For each day, a maximum of three types of activities could be recorded. To impute the steps for biking and swimming, the number of minutes spent biking and swimming was asked. In line with the guidelines of New Lifestyles [AQ: Identify this and give reference], after data collection, for every minute of biking and/or swimming, 130 steps counts were added to the day-end amount of the steps taken.

**Questionnaire.** The different domains of PA in a usual week (namely PA at work, transport-related PA, domestic and gardening activities, PA during leisure time, and the time spent sitting on a typical weekday...
and weekend day) were assessed with the IPAQ. The long-form telephone version and the self-administered version were both used. Both versions gave similar results, and the IPAQ was found to be a valid and reliable instrument to measure PA at population level in Europe (Craig et al., 2003) and in Flanders, Belgium (Vandelanotte, De Bourdeaudhuij, Sallis, Philippaerts, & Sjostrom, 2005). Based on the guidelines for data processing and analysis of the IPAQ (Guidelines, 2005), total scores for all walking, moderate and vigorous physical activities, and total scores for PA in the four domains, all expressed in minutes per week, were computed. The first question of the IPAQ asked about the employment status of participants (employed/unemployed). Two additional questions were added to the IPAQ to inquire about the number of years of education and the self-reported state of health (excellent/very good/good/moderate/poor).

Data Analysis

All analyses were conducted using SPSS 12.0 for Windows [AQ: Manufacturer, city, state]. Mean steps/day were evaluated for the whole sample and for groups defined by gender, age (25–35-year-olds, 36–45-year-olds, 46–55-year-olds, 56–65-year-olds, and 66–75-year-olds), employment status (employed vs. unemployed), and days of monitoring (weekday vs. weekend day) in a repeated measures ANOVA. The days of monitoring (weekdays vs. weekend days) were used as the within-subjects factor; gender, employment status, and age group as the between-subjects factors, and years of education as a covariate. The relation between groups based on the pedometer indices of Tudor-Locke and Bassett (2004) and the qualitative variable self-reported state of health were analysed with a chi-square test.

Similar to other studies, the skewed IPAQ data were first log-transformed to approximate normal distributions (Napolitano et al., 2003; Rzewnicki, Auweele, & De Bourdeaudhuij, 2002). Differences between the groups based on the pedometer indices of Tudor-Locke and Bassett (2004) in IPAQ results were tracked with MANOVAs. Results were adjusted for demographic variables, namely age, gender, and employment status. Parametric analyses were performed on the log-transformed IPAQ data: F-values, p-values and partial $\eta^2$, as a measure of effect size, are reported. The figures shown in Table 2 and in the results section are the means ($M$) and standard deviations ($SD$) of the nontransformed data. In addition, Pearson correlation coefficients were generated to compare between measured steps/day and the amount of PA reported in the IPAQ. Throughout, an alpha level of $p < .05$ was used to decide upon statistical significance.

Results

Adults in the present sample reported taking on average 9,655 ($SD = 4,526$) steps/day. In Table 1, steps/day are presented by gender, age, employment status, and days of the week. The results showed that men ($M = 9,906, SD = 5,046$) accumulated more steps/day than women ($M = 9,428, SD = 3,984$) ($F = 5.0, p = .026$). Steps also differed significantly across age groups ($F = 3.3, p = .01$). The most active group were the 36–45-year-olds ($M = 10,589, SD = 3,620$) who reported significantly more steps/day than all other age groups (36–45-year-olds vs. 25–35-year-olds [M = 10,258, SD = 4,188]: $p = .046$; 36–45-year-olds vs. 46–55-year-olds [M = 10,105, SD = 4,813]: $p = .046$; 36–45 year vs. 56–65-year-olds [M = 9,052, SD = 5,110]: $p = .004$; 36–45-year-olds vs. 66–75-year-olds [M = 7,693, SD = 4,255]: $p < .001$). The 46–year-olds were also significantly more active than the 66–75-year-olds ($p = .022$). Employed participants ($M = 10,323, SD = 4,234$) reported more steps/day than unemployed participants ($M = 8,282, SD = 4,841$) ($F = 6.2, p = .013$). And the whole sample took more steps on weekdays ($M = 9,755, SD = 4,727$) than on weekend days ($M = 9,433, SD = 5,954$) ($F = 7.4, p = .007$). No significant interaction effects could be found between

<p>| Table 1. Pedometer-determined physical activity (steps/day) |</p>
<table>
<thead>
<tr>
<th>n</th>
<th>Steps/day</th>
<th>$F(\text{df})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td>5.0 (*)</td>
</tr>
<tr>
<td>Men</td>
<td>598</td>
<td>9,906</td>
</tr>
<tr>
<td>Women</td>
<td>624</td>
<td>9,428</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td>3.3 (**)</td>
</tr>
<tr>
<td>25–35</td>
<td>237</td>
<td>10,238</td>
</tr>
<tr>
<td>36–45</td>
<td>267</td>
<td>10,589</td>
</tr>
<tr>
<td>46–55</td>
<td>287</td>
<td>10,105</td>
</tr>
<tr>
<td>56–55</td>
<td>248</td>
<td>9,052</td>
</tr>
<tr>
<td>66–75</td>
<td>183</td>
<td>7,693</td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td>6.2 (*)</td>
</tr>
<tr>
<td>Unemployed</td>
<td>396</td>
<td>8,282</td>
</tr>
<tr>
<td>Employed</td>
<td>826</td>
<td>10,323</td>
</tr>
<tr>
<td>Day of monitoring</td>
<td></td>
<td>7.4 (**)</td>
</tr>
<tr>
<td>Weekday</td>
<td>1,217</td>
<td>9,755</td>
</tr>
<tr>
<td>Weekend day</td>
<td>1,217</td>
<td>9,433</td>
</tr>
</tbody>
</table>

Note. $M =$ mean; $SD =$ standard deviation.
* $p < .05$.
** $p < .01$. 
these variables. The analysis did show a significant interaction effect between days of monitoring and the level of education ($F = 5.4, p = .02$). Further exploration showed that participants whose highest diploma was a high school qualification, took fewer steps on the weekend ($M = 8,896, SD = 6,522$) than on weekdays ($M = 9,544, SD = 4,936$), while there was no difference between days of monitoring (weekend: $M = 9,802, SD = 5,432$ vs. weekdays: $M = 9,912, SD = 4,544$) for participants who held at least a college certificate.

According to the pedometer indices of Tudor-Locke and Bassett (2004), 12.9% of the present population can be classified as sedentary (< 5,000 steps/day, $M = 3,504, SD = 1,215$), 19.4% were low active (5,000–7,499 steps/day, $M = 6,353, SD = 714$), 26.2% were somewhat active (7,500–9,999 steps/day, $M = 8,788, SD = 711$), 21.1% reached the recommended minimum 10,000 steps/day and can be classified as active ($M = 11,123, SD = 716$), and 20.5% were highly active with more than 12,500 steps/day ($M = 16,232, SD = 4,105$). Figure 1 shows the classification based on the pedometer indices according to age group. The relation between self-reported state of health and pedometer indexes was significant ($x^2 = 79.5, p < .001$). In the group that described their state of health as “poor,” 95.9% were sedentary, low active and somewhat active, while 55.8% of those who reported having an excellent state of health were active and highly active. No significant relation could be found between gender and groups based on the pedometer indices of Tudor-Locke and Bassett (2004).

Table 2 shows the IPAQ results for the different groups, based on the pedometer indices of Tudor-Locke and Bassett (2004). Significant differences between the five pedometer groups were found for time spent walking ($F = 17.5, p < .001, n_p^2 = .06$), moderate PA ($F = 14.7, p < .001, n_p^2 = .05$), and vigorous PA ($F = 8.1, p < .001, n_p^2 = .03$). The time spent walking differed significantly between most groups ($p < .05$), except between the somewhat active and active group, and between the active and highly active group. Significant differences in moderate PA were found between most groups ($p < .05$), except between the somewhat active and active group. Also, the differences in vigorous PA were significant for most pairs ($p < .05$), except between the sedentary and low active group, and between the active and highly active group. Taking into consideration the different domains of PA, our analysis showed significant differences between the five groups for PA at work ($F = 10.5, p < .001, n_p^2 = .03$), transport-related

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sedentary M, SD</th>
<th>Low active M, SD</th>
<th>Somewhat active M, SD</th>
<th>Active M, SD</th>
<th>Highly active M, SD</th>
<th>F(df)</th>
<th>Diff.</th>
<th>n_p²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>155 238</td>
<td>209 287</td>
<td>324 400</td>
<td>392 422</td>
<td>452 448</td>
<td>17.5* c, d</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Moderate PA</td>
<td>443 413</td>
<td>455 395</td>
<td>524 435</td>
<td>561 433</td>
<td>579 398</td>
<td>4.7* c</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Vigorous PA</td>
<td>42 153</td>
<td>68 229</td>
<td>119 287</td>
<td>164 318</td>
<td>152 297</td>
<td>8.1* a, d</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Work-related PA</td>
<td>75 269</td>
<td>198 479</td>
<td>357 635</td>
<td>503 715</td>
<td>517 703</td>
<td>10.5* a, b, d, e</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Transport-related PA</td>
<td>97 176</td>
<td>96 162</td>
<td>131 178</td>
<td>150 212</td>
<td>174 217</td>
<td>15.5* a, c, d</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Domestic-garden PA</td>
<td>422 472</td>
<td>379 416</td>
<td>400 442</td>
<td>379 401</td>
<td>344 372</td>
<td>2.3 ns</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Leisure-time PA</td>
<td>96 153</td>
<td>111 167</td>
<td>151 230</td>
<td>162 221</td>
<td>236 274</td>
<td>2.1* b, c</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Sitting</td>
<td>2,903 1,222</td>
<td>2,937 1,253</td>
<td>2,916 1,260</td>
<td>2,538 1,134</td>
<td>2,390 982</td>
<td>10.1* a, b, d, e</td>
<td>.03</td>
<td></td>
</tr>
</tbody>
</table>

Note. $M =$ mean; $SD =$ standard deviation; $PA =$ physical activity; a = no significant difference between sedentary and low active group; b = no significant difference between low active and somewhat active group; c = no significant difference between somewhat active and active group; d = no significant difference between active and highly active group; e = no significant difference between sedentary and somewhat active group; ns = not significant ($p > .05$)

*p ≤ .001
PA ($F = 15.5, p < .001, n_p^2 = .05$) and leisure time PA ($F = 12.1, p < .001, n_p^2 = .04$). Some differences between pairs for PA at work (sedentary and low active group, low active and somewhat active group, sedentary and somewhat active group, and active and highly active group), for transport-related PA (sedentary and low active group, somewhat active and active group, and active and highly active group), and for leisure time PA (low active and somewhat active group, and somewhat active and active group) were not significant. Also, time spent sitting differed significantly between most groups ($F = 10.1, p < .001, n_p^2 = .03$), except between the sedentary and low active group, the low active and somewhat active group, the sedentary and somewhat active group, and the active and highly active group.

Steps/day were negatively correlated to the time spent sitting per week ($r = -.15, p < .001$) and positively related to PA at work ($r = .24, p < .001$), transport-related PA ($r = .18, p < .001$), and PA in leisure time ($r = .20, p < .001$). The domestic and gardening PA was not significantly correlated to the number of steps/day ($r = -.001, p = .96$). The three categories of PA were also positively correlated to the number of steps/day (walking: $r = .20, p < .001$, moderate PA: $r = .15, p < .001$ and vigorous PA: $r = .22, p < .001$).

Analysis of the activity log showed that 58.5% of the sample reported some sports or physical activities during the week of pedometer registration. The remaining 514 (41.5%) participants reported no sports or physical activities over the entire week. One hundred fifteen participants (9.3%) reported some PA on 5 days or more during the week of self-registration. The three most frequently reported sports or PA categories were walking, fitness activities, and jogging. Six participants reported three activities on at least one day. About 41% of all participants engaged in bicycling during the week of pedometer registration. For these participants, a mean of 7.6 ($SD = 17.6$) minutes/day of biking (1,140 [$SD = 2,640$] steps/day) was imputed to the day-end steps taken. About 4% engaged in swimming over the seven days of registration ($M = 0.3$ min/day, $SD = 1.8$).

Discussion

The first aim of the present study was to provide pedometer-based PA levels in a sample of Belgian adults and to compare step counts between gender, age groups, employment status, and days of monitoring. The entire sample of 25–75-year-old Belgian adults took on average 9,650 ($SD = 4,520$) steps/day. When comparing this mean step count to other pedometer-based study findings, the present sample is more physically active than other populations (Tudor-Locke, Ham et al., 2004; Wyatt et al., 2005). However, the large standard deviation reveals a wide distribution of ambulatory behavior in the present sample. In the United States, mean population levels of pedometer-determined PA were about 6,000 ($SD = 3,700$) steps/day for South Carolina citizens ages 18–65+ years (Tudor-Locke, Ham et al., 2004) and 6,800 steps/day for Colorado residents ages 18–60+ years (Wyatt et al., 2005). In Australia, PA levels were higher than in the United States. Consequently, the present PA level is more comparable to the levels of Australian workers (8,900 steps/day; Miller & Brown, 2004), Australian young women (9,000 steps/day; Brown et al., 2002), and the Western Australian population (9,695 steps/day; Mc Cormack et al., 2005). The only European pedometer-based study was performed in 1989 (Sequeira et al., 1995). The average number of step counts for Swiss men dropped from 11,900 steps/day in the 25–34-year-olds to 6,700 in the 65–74-year-olds and from 9,300 to 7,300 for Swiss women. In the present study the average amount of steps/day for men decreased from 10,600 in the youngest age group to 8,500 in the oldest age group and from 9,800 to 6,900 for women. No other recent data of European levels of pedometer-determined PA are available, so the present study is the single largest survey of adult pedometer-assessed PA in Europe in the 21st century.

When preparing the dataset, no cut-offs were used to limit high step counts. To encounter the problem of
using mean steps/day, which are sensitive to extreme values, the recently introduced pedometer indices of Tudor-Locke and Bassett (2004) are helpful. Although the mean number of steps/day of the present population was high, classification based on pedometer indices showed that 58.4% of the entire sample was sedentary, low active, or somewhat active and did not reach the 10,000 steps/day standard. However, again, the percentage of the population reaching the recommended level is higher than it is in the United States. In South Carolina (Tudor-Locke, Ham et al., 2004), only 13.9% of the population took more than 10,000 steps/day, and in Colorado (Wyatt et al., 2005), no more than 16% could be classified as active or highly active. In the Australian study, 47% of the population reached the 10,000 steps standard (McCormack et al., 2005). The classification based on pedometer indexes by Tudor-Locke and Bassett (2004) was not used in other Australian studies. Therefore, it was impossible for us to make any comparison. Similar to the findings made by Rutten et al. (2001), the present results on the relation between self-reported state of health and pedometer indices showed that people with a poor state of health were predominately inactive. However, due to the cross-sectional study design, the direction of causality cannot be addressed. Further research is needed to examine the directionality on this interesting finding.

A variety of different explanations exists for the differences in PA levels between Belgium and the United States. Environmental characteristics (e.g., bike lanes) and socioeconomic characteristics (e.g., health care) differ between Europe and the United States, and there is a relation between socioeconomic status (i.e., PA is more prevalent in higher socioeconomic classes; USDHHS, 1996), environmental variables (De Bourdeaudhuij, Sallis, & Saelens, 2003; USDHHS, 1996), and PA. Given this information, it is likely that PA levels in European countries differ from those in the United States. An earlier survey (De Bourdeaudhuij & Sallis, 2002) revealed that the activity levels of Belgian adults were higher than those of the American sample. However, it is worth bearing in mind the following when comparing the Belgian and United States findings. First, data collection in the two studies in the United States (Tudor-Locke, Ham, et al., 2004; Wyatt et al., 2005) were completed in winter, while data in the present study were collected during spring. Tudor-Locke, Bassett et al. (2004) suggested considering the impact of seasons on pedometer-determined PA and suggested to plan for data collection in the fall or spring. Second, in the present study the day-end steps were increased with the equivalent in steps for the time spent biking and swimming. In the other studies (Brown et al., 2002; Miller & Brown, 2004; Sequeira et al., 1995; Tudor-Locke, Ham et al., 2004; Wyatt et al., 2005), no information was available on the processing of these nonambulatory activities. However, it should be mentioned that, in the present study, the equivalent in steps was based on data in the activity log, and the validity of this self-report instrument is unclear. Also note that, in the present study, employed participants were more likely to complete the pedometer protocol than participants who did not have a job. Furthermore, conclusions about differences between samples must be drawn with caution, as the recruitment approaches adopted in the various studies were different. Moreover, the validity, accuracy, and reliability may vary between different types and brands of pedometers (De Cocker, Cardon, & De Bourdeaudhuij, 2006; Schneider et al., 2003), and slow walking speeds (< 60 m/min), often occurring in elderly or sick individuals, may also be a source of error (Bassett et al., 1996). Finally, as yet no scientific agreement exists on the processing of nonambulatory activities.

Notwithstanding the variation in mean levels between different studies, similarities with other pedometer studies and earlier PA research (USDHHS, 1996) can be found. Similar to other pedometer studies (Bassett et al., 2004; Sequeira et al., 1995; Tudor-Locke, Ham et al., 2004), men accumulated more steps/day than women. However, these findings need to be interpreted with caution since a variation of 500 steps/day may have limited biological value. Wyatt et al. (2005) found no significant gender differences in steps/day. Although the most active group were the 36-45 year-olds, the results showed a decline in mean steps/day with increasing age. The same was found in other countries (Sequeira et al., 1995; Tudor-Locke, Ham et al., 2004; Wyatt et al., 2005). Despite the increased leisure time on the weekends (Brail & Chain, 1973), more steps/day were accumulated on weekdays than on weekend days, a finding also shown in other studies (Bassett et al., 2004; Miller & Brown, 2004; Sequeira et al., 1995; Tudor-Locke, Bassett et al., 2004; Tudor-Locke, Ham et al., 2004). Again, despite the statistical significance, the practical significance is unclear. The present finding that employed participants accumulated significantly more steps/day than unemployed participants was inconsistent with the results of the study by Chan et al. (2003), where full-time workers (7,100 steps/day) were less active than part-time workers (9,600 steps/day), although it should be pointed out that in the latter study the place of recruitment was a predominately sedentary worksite.

A second objective of the present study was to evaluate differences between groups based on pedometer indices of Tudor-Locke and Bassett (2004) in work-, transport-, home-, and leisure time-related PA reported in the IPAQ. The results showed that the
classification of activity level based on pedometer data corresponded to differences in self-reported levels of PA (low to medium effect sizes). The more active participants were, based on pedometer data, the higher their work-, leisure time-, and transport-related PA as reported on the IPAQ. Similar results were found for the amount of time spent sitting: low active groups (classified on pedometer data) reported more time spent sitting than active groups. Consequently, pedometer data are capable of discriminating between levels of PA reported on the IPAQ. Sequeira et al. (1995) found that pedometers were able to discriminate between sitting, standing, and moderate effort categories as well. Hence, the present study confirms the usefulness of the pedometer in objectively assessing PA in free-living conditions in large populations. In line with these findings, significant correlations were found between objectively measured step counts and subjectively reported levels of activity. Although the results showed statistically significant correlation coefficients between step counts and PA at work ($r = .24$, $p < .001$), leisure time PA ($r = .20$, $p < .001$), and transport-related PA ($r = .18$, $p < .001$), the coefficients are relatively small. By contrast, Bassett et al. (2004) found moderately significant associations ($r = .47$) between pedometer values and IPAQ scores in adults from an Amish community.

The most frequently reported sports or physical activities in the present study (walking, fitness activities, and jogging) were also the most popular sports or exercise forms reported in earlier American (Tudor-Locke, Bassett et al., 2004; Tudor-Locke, Ham et al., 2004) and European studies (Uitenbroek & McQueen, 1991). Although similarity was found in terms of activity popularity, the percentage of participants that reported engaging in some form of sports or exercise was different. Tudor-Locke, Ham et al. (2004) found that 89% of participants reported some activity on at least one day of the monitoring period, whereas the present results showed that 58.5% of the participants were active on at least one day. Analysis of the activity log showed that only 9.3% reported engaging in sports or exercise on at least five days of the week, whereas the recommendation is to accumulate a minimum 30 min of moderate to vigorous PA on most, preferably all, days of the week (ASCM, 2000; USDHHS, 1996). Taking this recommendation into consideration, the present sample could be classified as sedentary. On the other hand, when pedometer-based PA levels are analysed, this sample is relatively active compared to American samples. As such, it is possible that the majority of the Belgian sample accumulated more steps during working hours or other activities (e.g. transport activities) that were not classified as sports or exercise and are therefore not represented in the activity log. This is reflected in the comparison of IPAQ scores between the five pedometer groups. Significant differences between the five pedometer groups (Tudor-Locke & Bassett, 2004) were found for non-sport or non-exercise activities, namely PA at work and transport-related PA. Other studies also found that occupational activity (Chan et al., 2003; Sequeira et al., 1995; Tudor-Locke, Ham et al., 2004) and walking for transport (Tudor-Locke, Bittman, Merom, & Bauman, 2005) have an important role in total daily PA. For domestic and gardening PA, which also include non-sport or non-exercise activities, no significant differences were found between the five pedometer groups. It is possible that these activities do not have a significant impact in total daily PA.

The reliance on self-reported PA data drawn from the activity log, which remains to be validated, is a limitation of the present study. A second weakness is the lack of information on BMI or other physiological parameters, marital status, job classification, and income. Future studies could focus on the relation between pedometer-determined PA and other descriptive variables. Furthermore, similar studies to be conducted in Europe, the United States, and other continents could enable further international comparisons. Moreover, this dataset can be used as a baseline to evaluate the effects of programs designed to increase population PA levels in Flanders. Based on the present mean values of daily steps, 10,000 steps/day could be an achievable goal for this population, although managing 10,000 steps/day will be harder for older participants than for their younger counterparts. As mentioned earlier (Wyatt et al., 2005), gradually building up to an activity level by making small, incremental increases in PA could be a successful strategy for the most inactive of groups.

In summary, the present findings provide information about pedometer-assessed PA in a sample of Belgian adults. The Belgian sample accumulated higher pedometer-determined PA levels than those reported in samples of the United States. Additionally, pedometer-determined data provide adequate information to discriminate between levels of PA reported on the IPAQ, which confirms the value that pedometers can have in PA assessment in large, free-living populations.

References


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