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MULTI-INSTRUMENT ASSESSMENT OF PHYSICAL ACTIVITY IN FEMALE OFFICE WORKERS

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Abstract
Objectives: The aim of this study was to examine the multi-instrument assessment of physical activity in female office workers. **Material and Methods:** Fifty healthy women (age (mean ± standard deviation): 34.8±5.9 years, body height: 158±0.4 cm, body weight: 61.8±7.5 kg, body mass index: 24.6±2.7 kg/m^2) workers from the same workplace volunteered to participate in the study. Physical activity was measured with the 7-day Physical Activity Assessment Questionnaire (7-d PAAQ), an objective multi-sensor armband tool, and also a waist-mounted pedometer, which were both worn for 7 days. **Results:** A significant correlation between step numbers measured by armband and pedometer was observed (r = 0.735), but the step numbers measured by these 2 methods were significantly different (10 941±2236 steps/day and 9170±2377 steps/day, respectively; p < 0.001). There was a weak correlation between the value of 7-d PAAQ total energy expenditure and the value of armband total energy expenditure (r = 0.394, p = 0.005). However, total energy expenditure values measured by armband and 7-d PAAQ were not significantly different (2081±370 kcal/day and 2084±197 kcal/day, respectively; p = 0.96). In addition, physical activity levels (average daily metabolic equivalents (MET)) measured by armband and 7-d PAAQ were not significantly different (1.45±0.12 MET/day and 1.47±0.24 MET/day, respectively; p = 0.44). **Conclusions:** The results of this study showed that the correlation between pedometer and armband measurements was higher than that between armband measurements and 7-d PAAQ self-reports. Our results suggest that none of the assessment methods examined here, 7-d PAAQ, pedometer, or armband, is sufficient when used as a single tool for physical activity level determination. Therefore, multi-instrument assessment methods are preferable. Int J Occup Med Environ Health 2016;29(6):937–945

Key words:
Physical activity, Questionnaire, Sedentary lifestyle, Female office workers, Pedometer, Sensewear armband

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INTRODUCTION

Currently, employees, especially office workers, spend most of their time at offices, and this likely shapes their daily life style and physical activity behaviors. This universal trend is thought to negatively affect office-based working people. Moreover, proliferation of technological advances in office equipment, including personal computers, desktop photocopiers and mobile phones, have gradually resulted in even light physical activity being unnecessary in the office environment, leading to increasingly sedentary behaviors that are associated with impaired health of office workers [1–3]. The consequences of these sedentary behaviors include: increased risks of job-related musculoskeletal diseases, body weight gain and the development of chronic diseases in the early stages of life [1,4]. Thus, it is not surprising that many studies have demonstrated that regular physical activity is beneficial in preventing numerous major chronic diseases and, thereby, reduces the risk of all-cause mortality and improves health [1]. Therefore, accurate and proper assessment of occupational physical activity is an important but challenging task for health researchers [5].

In particular, it is difficult to assess light intensity physical activity via self-report, but such activity may have important health implications for workers if it replaces long hours spent to perform sedentary tasks [6–8]. In contrast to subjective assessment through self-report, use of individual monitors, such as pedometers or armbands, may provide an objective measure of human behavior. Specifically, armbands estimate energy expenditure and time-stamped physical activity patterns (including steps taken) [9]. In addition to armbands, pedometers can also estimate total steps taken, while they are more practical, user-friendly, and easily accessible [10,11]. Pedometers are very useful for capturing behavioral context (e.g., type of behavior, physical and social environment, etc.). However, because no single measuring instrument is currently able to fully capture human behaviors accurately and in context, concurrent assessments that integrate multiple types of instruments may yield important insights into occupational physical activity [7,12,13]. For example, individual monitors, including multi-sensor armbands and simple pedometers, may be paired with self-report questionnaires to yield a potentially synergistic array of information about a worker's physical activity and sedentary behaviors in a specific context [12,14].

Recent studies [7,9,15] have examined the combined use of subjective and objective methods for the assessment and measurement of physical activity. However, there have been few direct attempts to examine the physical activity of women employed in desk jobs. Therefore, this study has attempted multi-instrument assessment of physical activity in female office workers.

MATERIAL AND METHODS

Participants and overview of procedures

Fifty 25–49 year-old sedentary premenopausal female office workers from one workplace with no chronic or acute health conditions, such as pregnancy, infectious diseases, chronic diseases or musculoskeletal disorders that could affect their ability to engage in physical activity, volunteered to participate in this study and provided signed informed consent. The workplace was a Turkish Ministry of Health department, and all of the workers there had graduated from a university with at least a bachelors' degree and were employed in sedentary clerical/administrative desk jobs. Out of 60 women elicited in the initial screening, only 58 met all inclusion criteria and agreed to participate in the study. The 58 female participants were divided into 3 groups according to age (group 1: 20–29 years, group 2: 30–39 years, and group 3: 40–49 years). During the study, 3 subjects from group 1, 1 subject from group 2 and 4 subjects from group 3 (a total of 8 women) were excluded due to failure (attributable to sickness, negligent absence and insufficient day-long device wear time) to comply with the inclusion criteria, resulting in a dropout rate of approximately 14%. The final study group included 50 women. Data were collected from October 2011 to May 2012. All participants were asked to not make any changes to their typical daily work and leisure time routines during the monitoring week. The study protocols were approved by the Research Ethics Committee of Ankara University and were implemented in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki.

Data collection

Standardized testing procedures were used for anthropometric measurements [16]. To examine physical activity level, the researchers applied a 7-day Physical Activity Assessment Questionnaire (7-d PAAQ) that had previously been tested and had reliability of 0.84–0.98 (all $p < 0.001$, $N = 113$) and validity of 0.51–0.89 ($N = 25$) in 18–65-year-old Turkish individuals in different occupational groups [17]. The questionnaire, which is similar to the short version of the International Physical Activity Questionnaire (IPAQ short), allowed the researchers to collect information about the frequency and duration of all physical activity (moderate, vigorous and walking) efforts practiced by the respondents in the study week. The weekly energy expenditures for each of the 6 activities (business, non-business, transportation, sports, stairs, sleep) were calculated following standard calculation methods [18]. On the basis of the calculated values (expressed in metabolic equivalent/week (MET/day), total energy expenditures were determined in terms of kcal/day. The JS-300 pedometer (JUNSD Industry Co., Ltd., China) was attached to the waists of participants to track the numbers of steps taken for 7 consecutive days. Before the intervention, the "walking test of 100 steps" and "shake test" were applied to determine the validity of the pedometer used in the present study. A pedometer was considered inaccurate when the error rate was ≥ 5% (i.e., ≥ 5 steps out of 100) in any of the tests [19]. The scores of the pedometer tests were accurate (2% and 1% for "walking test of 100 steps" and "shake test," respectively). Subjects were instructed to wear the pedometer (during waking hours, approx. 14 h/day) and to record the pedometer-determined steps in a log book the night prior to retiring.

A multi-sensor body monitor, the Sensewear Armband (BodyMedia, USA), was worn over the triceps area of the dominant arm and had previously been shown to have satisfactory reliability and validity [20,21]. It continuously collects various physiological and movement information through multiple sensors to assess total energy expenditure, number of steps and physical activity levels of participants according to the manufacturer's algorithms [22]. The participants were instructed to wear the armband 24-h/day for 7 consecutive days, except during water-based activities. A valid study day was one in which at least 1368 min/day of armband data were recorded, which corresponds to a day-long wear time of 95%. Data were downloaded from the armband and then analyzed using Sensewear professional software (version 7.0).

Basal metabolic rate (BMR) for study females was calculated using the following formula [23]:

$$\mathrm{BMR} = 9.6 \times \mathrm{weight\ (kg)} + 1.8 \times \mathrm{height\ (cm)} - 4.7 \times \mathrm{age\ (years)} + 655 \tag{1}$$

Total energy expenditure obtained from the armband (armband TEE) was also used to calculate physical activity level (PAL) [24]:

$$\mathrm{PAL} = \frac{\mathrm{armband\ TEE}}{\mathrm{BMR}} \tag{2}$$

Statistical analysis

All continuous data were reported as mean values and standard deviations (SD). The assumption of normality was verified using the Shapiro-Wilk test before performing parametric tests. For physical activity variables, one-way analysis of variance (ANOVA) was used to assess differences between age groups. A Tukey *post hoc* test was applied for pairwise comparisons between age groups. A paired t-test was used for all respondents to compare differences in steps/day measured by the armband and pedometer and to compare differences in total energy expenditure and physical activity level measured by the armband and questionnaire. The relationships between the measurement methods were assessed using Pearson's correlation. All statistical analyses were performed using SPSS version 16.0 (SPSS Inc., USA), and the level of statistical significance was set at $p < 0.05$.

RESULTS

Table 1 presents the descriptive physical and anthropometric characteristics of female office workers according to age group.

No differences in the measured physical activity characteristics were observed between the different age groups (Table 2). Additionally, no difference was found in the number of steps measured by the armband ($F = 1.26$, $p = 0.293$, $\eta^2 = 0.054$) and pedometer ($F = 2.92$, $p = 0.064$, $\eta^2 = 0.04$). No difference was found in total energy expenditure measured by the armband ($F = 0.599$, $p = 0.554$, $\eta^2 = 0.063$) and questionnaire ($F = 2.299$, $p = 0.112$, $\eta^2 = 0.067$).

Considering that there were no significant between-group differences, we decided to combine the data of the different age groups for the comparisons of different measurement methods. The armband showed that the women accumulated an average of 10 941±2236 steps/day, while the pedometer showed that they accumulated an average of 9170±2377 steps/day. There were significant differences in the number of steps measured by the armband and pedometer ($t = 7.43$, $p < 0.001$, Cohen's $d = 1.05$). Also, a significant moderate correlation was found between the number of steps measured by the armband and pedometer ($r = 0.735$, $p < 0.001$) (Table 3). In contrast to the number of steps, there were no significant differences in armband TEE (2084±197 kcal/day) and 7-d PAAQ TEE (2081±370 kcal/day) ($t = 0.05$, $p = 0.96$, Cohen's $d = 0.01$), but there was a significant weak correlation between these 2 measurement methods for TEE ($r = 0.394$, $p = 0.005$). Similarly, no relationship was

Table 1. Physical and anthropometric characteristics of female office workers

Characteristics	Respondents (M±SD)		
	20–29 years old (N = 15)	30–39 years old (N = 21)	40–49 years old (N = 14)
Age [years]	27.9±1.4	34.9±3.1	42.0±2.0
Height [cm]	156.5±4.6	159.2±4.3	160.2±4.2
Weight [kg]	60.2±7.0	60.6±8.4	65.4±5.8
BMI [kg/m^2]	24.6±2.7	24.1±3.2	25.4±2.1
WC [cm]	79.9±7.0	75.9±6.6	79.1±3.8
HC [cm]	98.3±5.5	100.6±6.4	104.6±5.0
WHR	0.8±0.1	0.7±0.0	0.7±0.0
PAL	1.4±0.2	1.4±0.1	1.5±0.1

BMI – body mass index; WC – waist circumference; HC – hip circumference; WHR – waist to hip ratio; PAL – physical activity level determined from the formula 2.
M – mean; SD – standard deviation.

Table 2. Comparisons of methods for physical activity assessment in female office workers*

Method	Respondents (M±SD)			p
	20–29 years old (N = 15)	30–39 years old (N = 21)	40–49 years old (N = 14)	
Armband STEP [steps/day]	11 650±2 521	10 818±2 359	10 367±1 576	0.293
Pedometer STEP [steps/day]	10 337±2 520	8 837±2 082	8 421±2 331	0.064
Armband TEE [kcal/day]	2 046±235	2 082±203	2 127±139	0.554
7-d PAAQ TEE [kcal/day]	2 087±344	1 972±351	2 239±393	0.112

* Physical activity variables represent averages, calculated as the average of the 7 monitoring days.
TEE – total energy expenditure; 7-d PAAQ – 7-day Physical Activity Assessment Questionnaire.
Other abbreviations as in Table 1.

Table 3. Correlation between questionnaire-based and objective methods for physical activity measurement in female office workers

Method	Measurement (M±SD)	Difference (p)	Correlation	
			r	p
STEP [steps/day]		0.000	0.735	0.000
armband	10 941±2 236			
pedometer	9 170±2 377			
TEE [kcal/day]		0.962	0.394	0.005
armband	2 084±197			
7-d PAAQ	2 081±370			
PAL		0.444	0.212	0.139
armband	1.45±0.12			
7-d PAAQ	1.47±0.24			

Abbreviations as in Table 1 and 2.

found between the armband and 7-d PAAQ PAL measurements (1.45±0.12 MET/day and 1.47±0.24 MET/day, respectively) ($r = 0.212$, $p = 0.139$) ($t = 0.66$, $p = 0.44$, Cohen's $d = 0.06$).

DISCUSSION

Physical activity is a complex behavior, and every domain of life (work, transport, domestic and garden, and leisure-time) should be researched separately [25]. In addition, accurate and proper assessment of occupational physical activity is an important but challenging task for health researchers [5]. Recent studies [7,9,15] demonstrated that subjective and objective methods can be used in combination for the measurement and assessment of physical activity. The purpose of this study was to examine multi-instrument assessment (armband, pedometer and questionnaire) of physical activity in female office workers in Turkey.

One of the major findings of the study was that the total number of the steps measured by the armband and pedometer were comparable among female office employees of all age groups and amounted to 10 941±2236 and 9170±2377 steps/day, respectively. These values are similar to the values obtained in the overall European population. Studies have shown that the average daily number of steps – 7854 in Turkey, 9655 in Belgium, 10 617 in Sweden, and 9500 in Finland – vary from country to country because of differences in climate conditions, transportation, pavement, roads and cultural factors [7,26].

Similarly, Thompson et al. [27] reported an average daily number of steps in women of 8354 and that the number of steps was lower among middle-aged women than among younger women. Chan et al. [28] found that the majority of working participants in federal or provincial government-funded departments or agencies considered their jobs to be moderately or highly sedentary, and the average number of steps reported in that study was approx. 7000 steps/day. Therefore, the numbers of steps observed in our study were higher than those observed in Chan et al.'s study [28]. This difference may be because workplace of our participants was very close to shopping malls near the city center, and our participants generally spent their lunch break and non-working hours window shopping.

A striking result of our study was that our participants are defined as physically active based on the number of steps recorded [11]; however, their calculated level of physical activity (1.45 MET) was low according to the PAL classification system [24]. Thus, although light intensity physical activity (walking) increases average daily step number, its contribution to the level of physical activity and daily total energy expenditure is fairly low. Similar to our study, a previous study reported an average daily number of steps of 11 979 and a physical activity level of 1.59 MET [29]. Number of steps is correlated with physical activity level in daily living conditions. Some researchers [11,30,31] have shown that in the absence of intensity determination, taking 10 000 steps/day is not sufficient to increase physical activity level.

Total energy expenditure values measured by armband and 7-d PAAQ were not different (2081±370 and 2084±197 kcal/day, respectively), but the relationship was weak ($r = 0.394$, $p = 0.005$). Alemán-Mateo et al. [32] found that females had the highest TEE value of 2123 kcal/day; which is similar to our findings. In addition to this similarity, some studies have shown that total energy expenditure varies depending on sex, age, body weight, etc. [1,29,32,33].

Furthermore, the present study demonstrated a significant correlation in the number of steps measured by the armband and pedometer ($r = 0.735$, $p < 0.001$). Colbert et al. [9] has reported significant correlations between the pedometer and armband step counts ($r = 0.87$). Similarly, in a previous study, a high correlation ($r = 0.94$, $p < 0.001$) was found between measurements made by an accelerometer and pedometer [26]. Some possible explanations for the differences between the findings of our study and those of previous studies include different numbers of participants, different occupational domains of the participants and differences in the measurement tools used (brands and features).

In the present study, total energy expenditure values and physical activity levels measured by the armband and 7-d PAAQ were similar and weakly correlated ($r = 0.21$ and 0.39, respectively). Similar studies showed a weak correlation between 2 objective measurement tools and a subjective measurement tool, with r values ranging 0.07–0.36 [7,15]. Those weak correlations may be due to various factors, such as patient characteristics and measurement tool features. Subjective methods are generally preferred in studies with larger populations, but they have the disadvantage of being less accurate at assessing housework, baby care, and physical activities of various intensities (walking, carrying, etc.) among sedentary adults [34]. Furthermore, level of education and recall bias affect the calculated physical activity level and total energy expenditure of subjective methods. This idea is supported by Jurakic et al. [25]. Because our participants had a higher (at least a bachelor degree) education level than that of average persons, their awareness of physical activity level was considered to be higher than that of the average persons; thus, the recall bias of our sample was thought to be lower than that of older-age subjects. Furthermore, employees with higher educational levels tend to have more sedentary occupations, as reported by multiple studies conducted in different populations [35,36].

Limitations and strengths of the study

There are several limitations of our study that should be taken into consideration before final conclusions are drawn. Firstly, while pedometers and armbands instantly measure physical activity, they fail to provide objective information regarding popular sports (cycling, swimming and gym training). Thus, they have to be combined with a questionnaire in large population-based studies to provide a more reliable picture of total physical activity level [7,26]. Secondly, it is generally believed that the use of pedometers increases motivation for physical activity, at least initially, and this motivation increases actual physical activity performance. A major strength of this study was the use of an armband worn over the triceps area of the dominant arm, as it allowed us to obtain measurements in free living and working conditions with satisfactory reliability and validity. Another major strength of our study was that the armband and pedometer were worn for 7 consecutive days; this is important because longer measurement period improves the accuracy of determination of physical activity.

CONCLUSIONS

Our results demonstrate that the number of steps measured by the armband and pedometer was different. Additionally, the total energy expenditures determined by the 7-d PAAQ and armband were similar. Our results suggest that use either of the 7-d PAAQ, pedometer or armband alone is insufficient and misleading for physical activity level determination in female office workers. For this reason, combined approaches with both objective and subjective measures should be preferred for the assessment and measurement of physical activity.

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