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Pedometers as an Effective Tool for Measuring Physical Activity in Young Females in Saudi Arabia

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Background: Pedometers are inexpensive and valid tools for monitoring physical activity. This study aimed to validate pedometers as an alternative option to Arab Teens Lifestyle (ATLS) questionnaire for evaluating physical activity in Saudi Arabia young women.

Methods: Ninety-nine female students, aged 19-23, were recruited at a female University in Riyadh, in Saudi Arabia. Participants wore HJ-203 OMRON pedometer for 7 consecutive days and at the end, they completed the part of ATLS questionnaire related to physical activity.

Results: Step count was significantly associated with total time spent on all physical activities (r=0.284; p=0.027) and time spent on high-intensity physical activities (r=0.308; p=0.006) but not with time spent on moderate-intensity physical activities (r=0.184; p=0.145). Step count showed a significant association with time spent in walking (r=0.289; p=0.008), one of the most frequent activities. Mean step count, low in both groups, was significantly higher in the group of active students compared to the inactive (6447±2426 vs 5035±2426; p=0.029).

Conclusion: This study encourages the use of pedometers instead of questionnaires to evaluate physical activity. Pedometers can also be a useful tool to promote physical activity in a population of Arab young female students, where walking is the most usual form of exercising.

Introduction

Regular physical activity (PA) promotes physical and mental wellbeing and strong evidence has demonstrated that active people have lower rates of several cardiovascular and metabolic diseases, as well as colon and breast cancer. On the other hand, physical inactivity is considered as the fourth leading risk factor for global mortality and one of the principal causes of major non-communicable diseases worldwide [1].

Several studies have shown that in Saudi Arabia (KSA) large proportions of the population are not meeting WHO recommended levels of PA and have increasingly sedentary lifestyles [2,3,4] due to the dramatic lifestyle changes related to rapid socio-economic development during recent decades [5]. The high inactivity levels, especially among females, [4]represent a major public health concern and there is an urgent need to develop effective policies and programs to encourage the adoption of an active lifestyle [6].

Consequently, researchers and health practitioners need valid tools to accurately assess PA and PA-related behaviors. Nevertheless, in Arabic populations, few studies exist assessing PA objectively (such as accelerometers and pedometers) [7,8], as well as intervention studies aiming at increasing women's PA levels [9,10].

Pedometers or step counters are low-cost and valid tools for measuring and monitoring PA in population studies [11,12]. These tools are easy to use, thus have a low burden for participants and provide a user-friendly output (steps/day). Several studies have shown the effectiveness and the feasibility of their use as motivational tools in pedometer-based intervention programs to promote PA, in particular for walking behavior [13,14]. A potential limit is the impossibility to discriminate for intensity of activity and to measure activities like biking, weight lifting and swimming. Nevertheless, walking is one of the most popular forms of PA in KSA women, together with household activities as shown in previous studies [2,15] and self-reported methods, as questionnaires, are not sensitive enough to appropriately measure

the amount of walking per day [16].

For these reason we can assume that a pedometer (which is designed to measure walking) may be the most appropriate instrument to capture usual PA in this specific population and can replace the currently administered Arab Teens Lifestyle (ATLS) questionnaire. Pedometers can also properly evaluate possible increases in PA during intervention studies.

Step counts were associated with self-reported PA in two studies in which pedometers were compared with four different questionnaires These articles concluded that pedometer-based data could discriminate the amount of PA done daily [17,18]. The ATLS questionnaire itself has been validated against pedometers[7].

Based on these premises, our primary aim is to validate pedometers as an alternative option to ATLS questionnaire for measuring PA.

Methods

The present study is a part of a larger protocol for a health promotion intervention study within the Princess Noura Bint Abdulrahman University (PNU). The rationale of that protocol and the reasons for choosing this target population have been already described elsewhere [2]. The previous study focused on describing the PA habits, self efficacy for PA and the relation of PA with perceived facilitators and

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barriers for young Saudi female students. The results of this study, together with the current study can establish the background for a future intervention study on PA in this population. The target population is the current study consists also of young Saudi female students for several reasons: (1) they are relatively easy to access, (2) the university is an open milieu susceptible to change and (3) universities can support health promotion initiatives through existing infrastructure (ex. available gyms).

For the current study a convenience sample based on students who volunteered to participate was used. The fact that the students volunteered (due to their engagement) was important in carrying out until the end of the process, which involved 7 days. We performed a cross sectional study involving 99 female students aged 19-23. Three students were excluded: one did not use the pedometer and two did not complete any of the information (age, weight, height, ATLS questionnaire). Ninety six students were included in the analysis. Participants were recruited during April 2015 at PNU, Faculty of Rehabilitation and Health Sciences, Riyadh, KSA. Each participant gave written informed consent to participate in this study. Ethical approval was obtained from the Ethics Committee College of Rehabilitation and Health Sciences PNU.

At the first stage, study participants were asked to complete a short questionnaire, which included basic demographic (age), and anthropometric characteristics (height, weight) (self-reported). They have been also handed the pedometer after a brief explanation on its use.After 7 days, the students returned back the pedometers. The researchers recorded the steps/day for the previous 7 days (stored in the memory on the device). The students also completed the part of ATLS questionnaire related to PA during the previous week and an additional open ended question related to how they felt about using the pedometer and if they had any difficulties or discomforts (for feasibility purposes).

HJ-203 OMRON pedometer was used in the present study. This tool uses a 2D piezoelectric acceleration sensor to detect steps count, offering additional mounting positions (pocket, backpack, handbag or necklace) to the traditional one (hip). Several studies have shown that in comparison to the older class of 2 spring-levered pedometers [19], these new piezoelectric instruments produce reliable and accurate results in laboratory and free-living conditions [20,21]. As an administration period of 7 days was enough to capture a usual week (both weekdays and weekends), participants were asked to wear the pedometer for 7 consecutive days during waking hours, removing it only while showering/bathing, swimming and sleeping. They could wear the instruments as a necklace, which has proved the ideal wearing position to achieve the best accuracy in controlled tests [21]. To limit pedometer reactivity students were also advised not to change their usual PA behavior during this period.

The ATLS questionnaire was chosen to investigate the type, intensity, duration (minutes/day) and frequency (days/week) of regular weekly PA in our sample. It is a validated self-administrated questionnaire developed for Arabic youth and young adults [22]. This questionnaire has been used in studies on PA among adolescents and young adults in KSA and other Arab countries [3,5,22].

The questionnaire explores a variety of light-, moderate-, and vigorous-intensity physical activities during a typical (usual) week, giving information on times/week and minutes/day for all individual activities. Pilot test results performed during the previous phase of the study [2] showed that only minor changes were required to adjust this questionnaire to the female-only setting at PNU. The original author of the ATLS approved these changes. For the present study, we included only the PA part of the ATLS questionnaire.

The questionnaire was delivered to the participants in the classrooms, after a brief introduction by the researchers and was self-compiled at home.

Statistical analyses were performed using the SPSS software, version 20 (IBM SPSS Statistics, IBM Corporation, Chicago, IL, USA).

Descriptive statistics (means, SD) were calculated to describe the socio demographic characteristics as well as individual ATLS items. Self-reported height and weight were used to calculate body mass index (BMI).

For the ATLS questionnaire, variables were created for the total minutes/week for each activity, for moderate- and high-intensity PA, and for total PA. The corresponding variables in terms of Metabolic Equivalent Task (MET) were also created (total MET-minutes/week for each activity, for moderate- and high-intensity PA, and for total PA).

Physical activities were assigned MET values based on the compendium of PA [23] and the compendium of PA for youth [24]. The following activities were categorized as moderate-intensity PA: normal-pace walking, swimming, moderate intensity sports and household work. The following activities were categorized as 'high-intensity' PA: brisk walking, running/jogging, cycling, self-defense sports, and weight training/body building. Moderate-intensity PA, except walking and household activities were assigned an average MET value of 4. Household activities were given an average MET value of 3, since it included some items that may require fewer than 3 METs (i.e. washing dishes, cooking, ironing) or other household activities that require 3 METs or more (i.e. vacuuming, gardening). Slow walking, normal-pace walking, and brisk walking were assigned MET values of 2.8, 3.5, and 4.5 respectively. Vigorous-intensity sports were assigned an average MET value of 8.

Individuals who had one or more missing values for a specific activity, were excluded in the calculations of total minutes/week and total MET-minute/week for moderate, high, and total PA. Participants were classified as physically active or inactive based on the achievement of the WHO PA recommendations levels, 1according to which young adults should reach a minimum of 150 minutes/week of moderate-intensity PA or 75 minutes/week of vigorous-intensity PA. This amount of exercise corresponds to a total of 600 meter-minute/week (150 minutes of moderate-intensity PA per week × 4 METs or 75 minutes of high-intensity PA per week × 8 METs). The percentage of active and inactive participants was finally calculated.

Average daily steps were calculated for each participant using the pedometers. To maintain consistency with previous literature [25,26] (suggesting that within a week, any combination of 3 days of pedometer data, even non-consecutive, can provide an adequate estimate of habitual weekly exercise), we decided to use data from participants having at least 4 days of pedometer counts (five participants had information available for less than 4 days). Moreover those with extremely low (<1,000 average daily steps) or extremely high (>25,000 average daily steps) step averages were verified and eventually excluded to remove outliers and unrealistic data [19].

Therefore, 7 participants in total were excluded from data analysis: the final pedometer-data analysis sample included 89 participants.

We refer to Tudor-Locke and Bassett pedometers cut points for healthy adults to classify levels of PA based on average step/days [27].

Moreover, Spearman's correlation coefficients (r_s) were calculated to assess the association between ATLS-based PA and average pedometer counts per day. Spearman correlations were chosen because PA data was not normally distributed and because this type of test is also less sensitive to the effect of outliers. We assessed the correlation between average number of steps per day and time (minutes) and METs spent during total, moderate- and vigorous-intensity PA. We also examined the relationships between pedometer data and time and METs spent for walking and running, the two activities that are better captured by the instrument.

Average step count was normally distributed, thus Student's t-test was used to test the difference in means of daily steps between the active and inactive students based on the cut-off value of 600 meter-minutes/week. $P < 0.05$ was considered as statistically significant.

Results

Table 1 (supplementary material) shows the demographic (age) and anthropometric characteristics (BMI), as well as the mean step counts, percentage of participants for each step count group and for physically 'active' and inactive' and ATLS-based levels of PA for each activity and for activities categorized as moderate- or high–intensity (both shown in total minutes/week and total MET-minutes/week).

Mean age was 20,8±1.0 years and mean BMI was 23.0±4.1. Mean daily step counts were5779±2498.

According to the pedometer indices' cut-off, 40.4% was classified as sedentary (<5.000 steps/day), 36.0% as low active (5.000–7.499 steps/day), 16.9% as somewhat active (7.500–9.999 steps/day) and 6.7% active (reaching the recommended minimum of 10.000 steps/day). Based on the cut-off of 600 meter minute/week for physically active and inactive 56.3% was active and 43.8% was inactive.

As shown in Table 1, walking, household work, and moderate intensity sports were largely the most frequent activities with 103±132, 117±194 and 86±265 minutes/week spent in them respectively. Time spent in the various high-intensity physical activities was very low. Total time spent in moderate PA was about three times higher compared to that spent in vigorous activity (298±339 vs 104±273). Considering moderate plus vigorous activity the students reached a mean of 422±582 minutes/week of exercising.

Table 2 shows the correlations between average pedometer daily counts and the time (minutes/week) and METs (MET-minute/week) spent on PA. Step count was positively significantly associated with total time spent on all physical activities (r=0.284; p=0.027), with time spent on high-intensity PA (r=0.308; p=0.006) but not with time spent on moderate-intensity PA(r=0.184; p=0.145).In addition, average steps count showed a positive significant association with time spent on walking (r=0.289, p=0.008) but not time spent on jogging (r=0.219; p=0.45). Regarding the other individual physical activities, we did not find a significant association with any of the activities (data not shown).

Descriptive characteristics of the participants		
	n	Mean±SD
Age (y)	95	20.8±1.0
BMI (kg/m^2)	96	23.0±4.1
Pedometers		
Pedometer steps counts (steps/day)	89	5779±2498
Step count range		
	Frequency	%
Sedentary (<5000 steps/day)	36	40.4
Low active (5000-7499 steps/day)	32	36.0
Somewhat active (7500-9999 steps/day)	15	16.9
Active (>10000 steps/day)	6	6.7
Active (600 MET min/week or higher)	36	56.3
Inactive (less than 600 MET min/week)	28	43.8
ATLS-questionnaire		
	n	Mean±SD
Individual physical activity (minutes)		
Walk (min/week)	89	103±132
Stairs (min/week)	94	14±10
Run/jog (min/week)	90	38±143
Cycle (min/week)	92	8±42
Swim (min/week)	93	4±17
Moderate intensity sports (min/week)	84	86±265
Self-defense (min/week)	93	0±5
Weight training/body building (min/week)	88	26±108
Household work (min/week)	75	117±194
Individual physical activity (MET)		
Walk (MET min/week)	88	369±483
Stairs (MET min/week)	94	115±82
Run/jog (MET min/week)	90	304±1143
Cycle (MET min/week)	92	67±339
Swim (MET min/week)	93	16±66
Moderate intensity sports (MET min/week)	84	344±1059
Self-defense (MET min/week)	93	5±39
Weight training/body building (MET min/week)	88	210±867
Household work (MET min/week)	75	350±582
Total minutes of physical activity		
Moderate (min/week)	68	298±339
High (min/week)	84	104±273
Total (min/week)	65	422±582
Total MET minutes of physical activity		
Moderate (MET min/week)	67	1017±1209
High (MET min/week)	84	788±2051
Total (MET min/week)	64	1986±3274

Table 1: (supplement material)Descriptive characteristics of the participants (n=96), average pedometer counts, ATLS-based weekly physical activity.

h: hours; MET: Metabolic Equivalent Task; min: minutes; n: number of students; SD: standard deviation; y: years.

	Spearman's rho	*p* value
Walk (min/week)	0.289	0.008
Walk (MET min/week)	0.292	0.008
Run/jog (min/week)	0.219	0.45
Run/jog (MET)	0.219	0.45
Total min/week of moderate physical activity	0.184	0.145
Total MET min/week of moderate physical activity	0.192	0.132
Total min/week of intense physical activity	0.308	0.006
Total MET min/week of intense physical activity	0.303	0.007
Total min/week of physical activity	0.284	0.027
Total MET min/week of physical activity	0.337	0.008

Table 2: Spearman correlation coefficients of pedometer average steps counts per day with the time (minutes/week) and METs (MET-minute/week) spent on physical activity derived from ATLS questionnaire.

MET: Metabolic Equivalent Task; min: minutes.

Similar findings were obtained for the associations between step counts and PA expressed in energy expenditure (MET-minute/week).

A Student's t-test was performed to compare mean daily step counts between active (n=34) and inactive (n=26) participants based on the cot off value of 600 meter minutes/week. Mean step counts, although low in both groups, was significantly (p=0.029) higher in the group of active students compared to the inactive participants (6447±2426 vs 5035±2426; p=0.029).

Discussion

In the current study, we used pedometers to measure usual (weekly) PA in a population of young Saudi female university students. Our results were similar to other studies with high physical inactivity levels in females [2,4]. Moreover, they were similar to a previous study in PNU female students with walking, moderate intensity activities and household activities being the most frequent and students engaging more in moderate than high intensity PA [2].

Based on step counts, this population was again classified as inactive with 76.4% considered as sedentary (<5000 steps/day) or low active (5000-7499 steps/day). Low step counts/day have been observed from the two other studies where pedometers were used to measure PA for Saudi female students [8,28]. Similarly to our study, they have described mean values of around 5000 steps/day as in our study.

The associations we found between step counts and different types of PA are of some significance. As expected, daily step counts were positively associated with walking and therefore they can be used in populations like this one where walking is a highly frequently activity. However, step counts were associated with walking, there was no association found with total moderate PA. This is probably because pedometers cannot capture the other activities that contribute considerably to moderate PA (household activities and moderate-intensity sports).

On the other hand, high intensity PA was positively associated with step counts and this is due to the proportion contributed by brisk walking. Total PA was also positively associated with step counts.

This is in agreement with previous studies on different populations [17,29,30]. Overall, in such a population where walking is very common, pedometers can reflect total PA and therefore can be a good alternative tool for the evaluation of PA. In addition to the above, and since walking is frequent, pedometers offer a more precise measurement for this specific type of activity compared to assessment through a questionnaire. Furthermore, future intervention studies encouraging walking, which is a feasible way of exercising and also the preferred chose in KSA can benefit from evaluating PA changes through pedometers. However, it has to be noted that other aspects of PA such as dancing (moderate-intensity activity) and household activities might be neglected when evaluating PA through pedometers. Therefore, it is suggested that pedometers are used with caution especially when conducting interventions where other aspects of PA other than walking are encouraged.

In addition, in the present study, we were able to discriminate levels of PA based on WHO recommendations (active and inactive) based on step counts. Other studies showed that the use of pedometers can make this distinction [17,18], suggesting that it can be a useful tool for categorizing populations such as the present one into active and inactive. However, when we look at the classification of PA based on step counts the prevalence is much lower (somewhat active: 16.9% + active: 6.7%) compared to the active based on WHO (56.3%).

Therefore, our results would preferably suggest that the more active a population is, there will be an average number of steps/day or meaning walking.

In the questionnaire distributed in the current study there was also a question referring to potential problems or comments from the participants in relation to the use of pedometers. Sixteen percent of students reported that they forgot to wear it on some occasion (they had to take it off while sleeping, showering or swimming) and 9% reported some difficulties such as not practical to wear it on weekends or annoying because they had to explain to others what it was. It is definitely expected that some small percentage of the population might have some complains since there is no perfect method of assessment. As for those who forgot to wear the pedometer, this might have biased the results to some extent but we were not able to measure it. However, our study showed results that were in agreement withother studies and that had plausible explanations. In addition, outliers were excluded from the analyses. Therefore, we assume that if they did not at any point forget to use their pedometers the results would have only reinforced the associations we found.

To our knowledge, this is the only study that tried to evaluate whether pedometers can be used as an alternative tool for measuring PA in young adults in KSA. We cannot assume that this can be a useful tool for assessing PA in young males since they might have other patterns of PA. On the other hand, we could consider that this tool might be of us for all young females, either university students or not since walking is the easiest and most usual activity in this population in KSA.

Another strength of our study is that we measured PA by pedometers for 7 days. As mentioned previously, any 3 days is considered enough to represent a usual week [25,26]. In our case, only 5 participants gave information for 3 days or less making the mean step count calculations per participant highly accurate.

Finally, the type of pedometer we used (necklace) is a good option for pedometer studies because it is accurate and user-friendly.

As for the limitations, the sample we used was a convenient sample consisting of university students studying health sciences. It is possible that many of the participants were more self-motivated in terms of wearing the pedometer and of being physically active compared to the general population. However, we found low PA levels and this suggests that our population was very similar to other very inactive female populations. As for the motivation in wearing the pedometer, this problem can be solved by thoroughly explaining to participantsits use and by offering some kind of incentive for individuals who participate in pedometers' studies.

Conclusion

In conclusion, our study suggests the use of pedometers as substitutes to PA questionnaires for young females in KSA. These populations are highly inactive and walking is one of the most common activities they undertake. Young females in KSA are a population with high significance in terms of health promotion and pedometers can prove as very useful tools for future intervention studies that encourage walking as a major activity.

Competing Interests

The authors declare that they have has no competing interests.

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