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How Accurate are Pedometer Cell Phone Applications?

A comparison between six applications

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Abstract

Accurate pedometers are useful tools to motivate and estimate physical activity. There are today free pedometer applications available for download to cell phones, thus enabling measurements by a device already worn. It is important to evaluate their accuracy and appropriate ways to wear the cell phone when using pedometer applications. The aim of this study was to evaluate the accuracy of six different free pedometer applications for three different cell phones, worn at three different cell phone positions. 10 test persons performed test sequences of 200 steps with each application, cell phone, and cell phone position. Only one application and cell phone combination showed a good accuracy with reasonable low standard deviation, especially in one of the cell phone positions. The majority of applications evaluated in this study, did not show high accuracy. There is a need of further evaluation of pedometer cell phone applications.

Keywords: Type your keywords here, separated by semicolons ; Pedometer; Cell Phone; Application; Physical activity

1. Introduction

Chronic diseases results in over three million preventable deaths globally every year [1]. Physical inactivity is one of the main causes of chronic disease [1-3]. Physical inactivity also leads to direct and indirect health care costs, and affect the quality of life and productivity [1]. The level of physical inactivity is increasing in many countries [4], and research even shows that it is dangerous for health to be sedentary too long [5].

Physical activity has positive impacts on several bodily functions [2, 6-9] and reduces the risk of chronic disease [1]. WHO has calculated that 80% of premature heart disease, diabetes and stroke are preventable [10]. The recommendation for physical activity in adults ranges from 11.000 to 12.000 steps for men and from 8.000 to 12.000 steps for women [11]. 10.000 steps/day and more indicates an active lifestyle [12].

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Pedometers are useful tools to motivate and measure physical activity [13]. The use of pedometers is associated with significant increase in physical activity, and contributes to decreased blood pressure and BMI [14]. But pedometers are capable of both under- and overestimating steps [15, 16], and to use inaccurate pedometers are not to recommend as it can lead to frustration and negative reaction to the device [17].

Today, the use of cell phones is very common. By the end of 2010, the number of cell phones subscriptions all over the world exceeded five billion [18], There are various applications (apps) for cell phones available for download, enabling the phone to be used as a pedometer, thus enabling measurements by a device already worn.

The aim of this study was to evaluate the accuracy of six different free pedometer applications for three different cell phones, worn at three different cell phone positions.

2. Methods

2.1 Test persons

In this study, 10 voluntary adults were included as test persons. 5 of these were male and 5 were female, with a mean age of 38 years, ranging from 23 to 51 years. Mean of BMI of the test persons was 25.8, ranging from 19.9 to 36.6, and the mean length was 1.76 m, ranging from 1.67 m. to 1.92 m.

2.2. Equipment and software

The cell phones used in the study were an iPhone (iPhone 4, Apple Inc., Californien, USA), a HTC (HTC Sensation, HTC Corporation, Taiwan) and a Sony E (Sony Ericsson Xperia Arc, Sony Mobile Communications, London, UK /Lund, Sweden).

The applications used for the iPhone were Ipedometer LITE (app 1), Pedometer Ultimate GPS+ (app.2) and Pedometer 24/7 FREE (app.3). The applications used for the HTC and Sony E were Pedometer by LexApps (app.4), Pedometer Levente Bagi (app.5) and Pedometer Luminant Software, Inc. (app.6). Applications 1-6 were all available for free download (Downloaded February 2012) and were frequently downloaded and regarded as popular. Application 1-3 were specially developed for the iPhone, whereas application 4-6 were developed for Android cell phones and were tested on both the HTC and the Sony E.

It was not possible to set the sensitivity level for application 1 and 6. For application 2-5, the sensitivity level was adjustable: for app 2-3, the sensitivity could be set on an analog scale and for app 4-5, six discrete levels were available. In this study, a medium level was chosen, i.e. for app 2-3, the sensitivity was set on the middle of the scale and for app 4-5, the level called medium was chosen.

2.3. Cell phone positions and measurements

The conducted measurements include three different cell phones, six selected pedometer applications (app 1-3 for the iPhone and app 4-6 for the HTC and Sony E) and three different cell phone positions.

The measurements were performed outdoors on a flat, straight road. The test persons performed 200 steps with each app and each of the cell phones placed on each of three cell phone positions (in the right chest pocket of the jacket, in the right pocket of the pants, and in a sport armband for cell phone, attached on the right upper arm, Fig. 1).

Fig. 1. Sketch of the cell phone positions: in the right pocket of the pants, in the right chest pocket of the jacket and in a sport armband for cell phone, attached on the right upper arm.

The steps were counted manually by the test person and one of the test leaders. For each test sequence of 200 steps, the distance was measured using a measuring wheel and the time was determined using a stop watch. The walking speed was calculated afterwards. To test all possible combinations of cell phones, apps and cell phone positions, the test person had to perform the test sequence of 200 steps 9 times. The test persons were instructed to walk in their normal walking speed.

3. Results

The test persons walked at an average speed of 1.6 m/s (min 1.4 m/s and max 1.9 m/s). Average steps registered by each cell phone, app and position, are shown in Table 1, Fig. 2a and 2b.

Table 1. Average steps measured by each cell phone, app and cell phone position for the test sequences of 200 steps.

Cell Phone	App nr	Chest pocket	Pants pocket	Sport armband
iPhone	1	124 ±96.8	152 ±140.8	73 ±57.7
iPhone	2	162 ±16.0	195 ±28.4	144 ±52.0
iPhone	3	100 ±18.6	143 ±23.6	90 ±9.8
HTC	4	206 ±79.3	302 ±108.4	159 ±27.0
HTC	5	230 ±72.6	290 ±73.6	162 ±24.1
HTC	6	128 ±57.8	139 ±90.6	145 ±61.1
Sony E	4	2 ±2.7	12 ±12.6	4 ±6.0
Sony E	5	3 ±1.9	43 ±92.8	15 ±14.8
Sony E	6	14 ±29.6	81 ±54.4	74 ±58.6

Comparing the different cell phone positions showed that app 2 (only available for the iPhone) had a high accuracy when placed in the pocket of the pants (195±28.4). However, this was the app and cell phone combination that showed the highest accuracy in all cell phone positions tested in this study. The result further showed that all individual apps, with one exception, estimated the highest number of steps in the pocket of the pants, independent on the cell phone. The exception was app 6 on the HTC, where the sport armband was the cell phone position with the highest number of steps estimated.

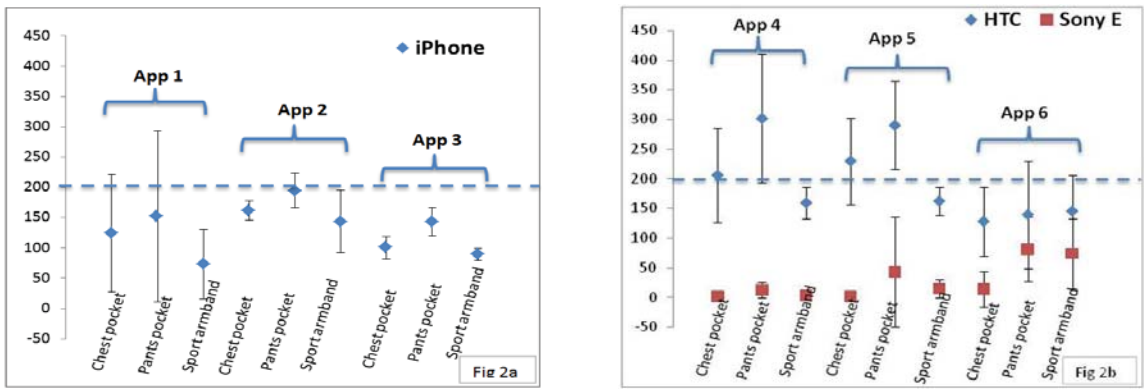

Fig. 2a) Average steps and standard deviation as measured by the iPhone for each app and cell phone position. Fig. 2b) Average steps and standard deviation as measured by the HTC and the Sony E for each app and cell phone position.

When comparing the three cell phones used in the study (Table 1, Fig. 2a and Fig. 2b), the iPhone showed the most accurate measurements. The iPhone showed low standard deviation in app 2 and 3, however the standard deviation for app 1 was high (57.7, 96.8, and 140.8, respectively). The apps tested for the iPhone did, with respect to the mean value, never overestimate the steps.

The measurements for the HTC and Sony E showed that app 4-6 had high standard deviations also for those apps with adjustable sensitivity level. For the HTC, app 4 and 5, relatively good accuracy was found with respect to the mean value in the chest pocket, but a high standard deviation was shown. These HTC apps overestimated the steps when placed in the pocket of the pants and showed a large standard deviation. However, the standard deviation for the HTC app 4 and 5 were acceptable when placed in the Sport armband.

Finally, the Sony E underestimated the steps severely for all apps and cell phone positions, Fig. 2b.

4. Discussion

In this study, the accuracy of six free pedometer cell phone apps was evaluated. The tests were performed on a flat straight road and with the cell phones placed at three different cell phone positions. A comparison of all test persons indicate that they were walking at about the same speed, so the actual speed during these tests is not evaluated further. When the selection of test persons was made, an equal number of each gender was chosen. The background parameters (age, BMI and length), were relatively similar between the test persons, and the study was not designed in order to investigate the effect of these background parameters.

The tests revealed that most of the apps showed a low accuracy and high standard deviation in estimating the number of steps. Most apps estimated a higher number of steps when placed in the pocket of the pants compared to the other cell phone positions. This indicates that this position generates extra movement of the cell phone, which is interpreted as extra steps. Possible difficulties with cell phones using pedometer applications, is that they can be worn in many different ways. Conventional pedometers can, depending on their design, be worn either in a well specified body position or in several body positions. For example, the Yamax Pedometer (Yamax Digi-Walker SW-200 /The Walk4Life MLS-2000 Yamax, Yamax Corporation, Tokyo, Japan), which has been used in several research studies [15, 19, 20], and is considered as suitable for

research purposes [15], should only be worn at the waist and have no possibility to adjust the sensitivity level. Therefore, it is important to evaluate the most suitable cell phone positions to use when introducing cell phone applications as pedometers.

The android apps, app 4-6, were tested on two cell phone models, HTC and the Sony E, in order to investigate the ability to perform accurate measurements and possible differences between cell phones. The result showed that there was a large difference, Fig. 2, dependent on which of the two Android cell phone that were used. In this study, the Sony E underestimated the steps to such an extent that it cannot be regarded as useful at all. However, only one individual cell phone of each model was tested. The iPhone apps were developed for this specific cell phone, which can explain its better accuracy. On the other hand, it would be possible to develop Android apps for a specific cell phone model, even if that has not been made today.

Two iPhone apps (app 2-3) showed low standard deviations in this study. These two apps also have the advantages that their sensitivity level can be adjusted analogously. There are also conventional pedometers that have the facility to set the sensitivity level. This makes it possible to better calibrate the app to different persons in practice. App 1, which was not adjustable for sensitivity level, also showed high standard deviation. Considering ordinary pedometers, it is not always possible to adjust the sensitivity level, even for pedometers validated and accepted for research purposes. The 20-Step Test is used by Tudor-Locke et al [19] to identify possibly problematic pedometers. In this test, the test person walks 20 steps in a normal walking speed with the pedometer correctly secured. An error greater than 1 step (= 5%) is considered to be unacceptable. The 20-Step could be more frequently used to calibrate the sensitivity level for different persons and cell phone positions.

In this study, only app 2 (available for iPhones) showed a high accuracy with reasonable low standard deviation, especially in one of the cell phone positions (pants pocket, 195±28.4). Pedometers are often used to motivate to physical activity. Over 10.000 steps/day is regarded as an indication for an active lifestyle [12]. If considering 10.000 steps performed and measured by this specific app, cell phone and cell phone position, this would correspond to an underestimation of approximately 250 steps, with respect to the average value. In a study by Vincent & Sidman [20], it was assumed that 5% error is acceptable in terms of pedometer measurements. By connecting the two above assumptions, calculations of the iPhone app 2 then generates an error of 2.5% by this specific app, cell phone and cell phone position, which could be considered as acceptable.

5. Conclusion

It can be concluded that only one app (app 2) and cell phone (iPhone) combination showed a good accuracy with reasonable low standard deviation, especially in one of the cell phone positions (pant pocket). It can also be concluded that the majority of applications evaluated in this study, did not show high accuracy. It might be possible to increase the accuracy if adjusting the sensitivity level on an individual bases, considering each person's motion pattern, cell phone, and cell phone position. There is a need of further evaluation of pedometer cell phone applications. When using cell phone pedometer applications for promoting the public health, it is of essential importance to also consider the measurement accuracy. If the measured steps can be trusted, the use of cell phone applications can be an easy and useful tool to motivate and measure physical activity.

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