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New Insights Into Compliance With a Mobile Phone Diary and Pedometer Use in Sedentary Women

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Abstract

Objectives—The purposes of this study were 1) to determine compliance with a pedometer and mobile phone-based physical activity diary, and 2) to assess concordance between self-reported daily steps recorded and transmitted by a mobile phone and pedometer-measured daily steps in sedentary women.

Methods—In this 3-week pilot clinical study, 41 sedentary women who met all inclusion criteria were recruited from local communities. We asked the participants to wear a pedometer every day and to report their daily steps using a mobile phone diary each night before retiring. In the first week, women were asked to monitor their daily steps (baseline steps). In the second and third weeks, they were asked to increase their steps by 20% from the previous week. Although the pedometer can automatically store the most recent 41 days' performance, the participants were not informed of this function of the pedometer.

Results—Overall compliance was 93.8% with pedometer use and 88.3% with the mobile phone physical activity diary. Bland Altman plots showed that the agreement between self-reported daily steps by mobile phone diary and pedometer-recorded daily steps from week 1 to week 3 was high.

Conclusion—The combination of a pedometer and a mobile phone diary may enhance the quality of self-reported data in clinical studies.

Keywords

physical activity; cell phone; diary; self-report; adherence; compliance; concordance

Studies assessing physical activity often require subjects to use self-report, including paper/pencil diaries, surveys, questionnaires, and interviews.¹ These self-report methods are relatively easy to administer, and are low-cost and convenient. Yet, data from these self-report methods often suffer from recall bias and response bias (eg, social desirability). For example, in paper/pencil diary methods, subjects tend to back-fill or forward-fill data, and

compliance with a paper/pencil diary tends to decline over time.^{2,3} Thus, it is important to understand how we can improve the compliance and quality of diary data from self-report methods to obtain accurate estimates of within-person changes and between person differences over time.⁴

Approximately 84% of adults in the United States use a mobile phone.⁵ More Americans own mobile phones than landline phones or even computers.⁶ Mobile technologies are easily adaptable and available to deliver behavioral intervention and/or to serve as a diary.⁷⁻⁹ Understanding how to use these devices effectively may enhance compliance and quality of data compared with traditional physical activity self-report methods. The potential features of these devices, such as no forward and backward-filling data entry, alarms and reminders of diary use, date and time stamped data entry, branching items based on user's response, instant access to data, and immediate feedback and acknowledgment in response to users' answers, can be implemented to a mobile phone diary to enhance compliance and quality of data.^{10,11}

We conducted a 3-week pilot study to examine the feasibility and acceptability of a mobile phone based physical activity intervention and mobile phone diary in sedentary women. In this pilot study, sedentary women were asked to wear a pedometer to record daily steps, and to enter their daily steps every night over the study period using a mobile phone diary incorporating the advantageous features described above. Fortunately, we had an opportunity to verify self-reported physical activity with recorded pedometer data. The aims of this paper were to 1) determine compliance in wearing the pedometer and recording steps in a mobile phone based physical activity diary, and 2) assess concordance between self-reported daily steps in the mobile phone diary and pedometer readings.

Methods

Study Design and Sample

A 3-week pilot study design was conducted from July to September 2008. We recruited potential participants from urban communities through newspaper announcements and flyers. Seventy-eight women were screened over the telephone, and were explained the details of the study involving a daily mobile phone and pedometer use. Of these 78 women, 47 visited a research office for further screening. Five women did not meet all inclusion criteria: (3 women had uncontrolled high blood pressure, 1 woman had a respiratory problem, and 1 woman had a reading problem). One woman declined to be in the study because the mobile phone program was too difficult for her to learn. In total, 41 sedentary women participated in the study. The study inclusion criteria were 1) age from 25 to 70 years; 2) ability to access a telephone at home and/or a mobile phone (if a participant lost a study mobile phone, we needed to contact the participant using another telephone number); 3) speaking and reading English; and 4) having a sedentary lifestyle screened by the Brief Physical Activity Survey questionnaire.¹² This questionnaire contained 2 items. The first item described different types of on-the-job activity and the second item described various leisure-time activities. Each item had 5 response choices. Each response choice included a global statement about the activity and the dimensions of frequency, intensity, time, and type of activity. The potential participants selected 1 response that best described her on-the-

job activity and 1 response that best described her leisure-time activity. Based on the answers, women were categorized into 5 groups: inactive, light-, moderate-, high-, and very high-intensity activity groups. To be in a study, women had to be either in the inactive or the light-intensity activity group. Exclusion criteria were 1) known medical conditions or other physical problems requiring special attention for an exercise program, 2) severe hearing or speech problems, and 3) current participation in lifestyle modification programs or research studies. We did not exclude women who had never used a mobile phone or were not a current mobile phone user. The pilot study was approved by the University of California San Francisco (UCSF) Institutional Review Board.

Procedure

Women who were interested in the pilot study were directed to call a research nurse. A research nurse screened potential participants over the telephone. If the participant met all inclusion criteria, she was scheduled for a first research office visit at the UCSF. After obtaining written consent, the research nurse obtained sociodemographic information and medical history. The research nurse also objectively measured the subject's weight and height to calculate Body Mass Index. Immediately following the structured interview, all participants received hands-on training in using the pedometer and daily mobile phone diary. Although 82.7% (n = 34) of the study participants owned a mobile phone, 43.9% (n = 18) of those participants did not know what types of mobile phone service they had. The remaining subject did not have the data plan (multimedia messaging service). Thus, we provided a MOTORAZRv3xx mobile phone, including voice, text messaging (short message service), and data plans (multimedia message service) to all participants during the 3-week study period. The JAVA based physical activity program was installed in each mobile phone. The program contained 2 parts: daily prompts and a mobile diary. All participants' responses to the daily prompts and the mobile diary were transmitted through a multimedia messaging service (MMS). If they did not use the mobile phone diary for 3 consecutive days, they received a text message and/or a call from the research nurse. All 41 women enrolled in the study completed the second research visit. At the end of 3 weeks, the recorded pedometer data were downloaded to a research computer. At the conclusion of the second research office visit subjects were paid \$20 to cover transportation and/ or parking expenses.

Intervention

The intervention consisted of 2 components: a brief face-to-face intervention at the beginning of the study and daily prompts during the study period. The brief face-to-face intervention contained 5 domains: (1) overview of the physical activity program (eg. weekly goal settings), (2) information regarding the importance of physical activity, (3) counseling to identify barriers to increasing physical activity, (4) increasing social support for physical activity, and (5) safety for physical activity. Over a 3-week period, participants were asked to wear a pedometer and to record and send their total number of steps through the mobile phone before going to bed. In the first week, women were asked to monitor their daily steps (baseline steps). In the second week, women were asked to increase their steps by 20% from their baseline number of weekly average steps, and in the third week, women were asked to increase their steps by another 20% from their second weekly average step count. The goals of weekly average steps were automatically set up based on patients' self-reported steps

through the mobile phone. In addition to the face-to-face intervention, participants were asked to respond to a daily prompt once a day. Daily prompts addressed the content of the face-to-face intervention. An automated text message was sent to each participant to open a daily prompt. Each daily prompt started with a message from the researcher, followed by a question relevant to the message. For example, women received the following daily prompt from the researcher: “Getting support is one of the most important things you can do when becoming more active. Do you have someone who could be your support or be active with you today?” Women selected “no” or “yes” by pushing the keypad. If women selected “no,” the next screen displayed “Find at least 2 people you can contact this week who will help keep track of your activity for reaching your goals.” If women selected “yes,” the next screen displayed “Great!”

Measures Pedometer

We used the Omron HJ-720ITC Pocket Pedometer which is designed with a USB Connection and PC Software. It measures total daily steps, total daily aerobic movement (steps), calories, and distance; with an error rate of less than 1% for steps.¹³ If participants walked briskly and continuously for more than 10 minutes, it displayed this activity as aerobic movement. The Omron HJ-720ITC Pocket Pedometer automatically reset the step count every evening at midnight but allowed subjects to view the past 7 days of total daily steps, total daily aerobic movement (steps), calories burned, and distance. The pedometer could display the prior 7 days of recorded data, and automatically stored the performance during the most recent 41 days, but could not be reviewed after 7 days. The participants were not told that the pedometer could store 41 days’ worth of performance. Compliance with the pedometer was defined as a “yes” response to the query “Did you wear a pedometer all day today, except for showering, swimming, sleeping?” in the mobile phone diary and evidence of recorded steps in the pedometer. When women answered “yes” to the above question and observed pedometer recorded steps throughout that day or when women did not answer the above question, but the pedometer recorded steps throughout that day, we defined this as compliance. Since each participant could have a total of 21 days to wear the pedometer, compliance with a pedometer was defined as the total number of days in wearing pedometer divided by 21 days.

Daily Mobile Phone Diary

Participants were asked to use a mobile phone diary to record their daily steps, duration, intensity and frequency of physical activity before going to bed. Participants were able to access the mobile phone diary only after 7 PM to midnight to prevent back-or-forward filling of data. If women did not use the diary by 8:30 PM, an automated text message reminded them to record the total number of steps per day and the types, duration, and intensity of physical activities. The mobile phone diary program was designed such that subjects had to answer every question in a sequential manner. For example, when a woman selected “diary,” she would see the first question, “Did you wear a pedometer all day today, except for showering, swimming, sleeping?” If the answer was “yes,” she was asked to enter the number of steps in a box. To increase accuracy of data entry, women were asked 1 more time whether the entered number was correct if the answer was greater than the maximum of 20,000 steps or fewer than 1000 steps. The participant immediately received a daily step bar

graph that showed the daily step count, so that she was able to self-monitor/visualize her progress and received immediate automated feedback in the mobile phone diary. Dependent on their daily step goal achievement, participants received a green, yellow, or red bar graph each night, followed by a short encouraging message. If the answer was “No” (the pedometer had not been worn), the woman was asked to select a reason why she did not wear it. The woman received a recommendation based on the selected answer. When women made entries in the mobile phone diary, they were not able to access it again the same night. Each participant was allotted a total of 21 days of data entry in making a diary entry/night. Compliance with mobile phone diary was defined as the total number of days in making a diary entry/night divided by 21 days.

Other Measures

A research nurse asked each participant about their past history of mobile phone use and pedometer use. The questions were as follows “Did you use a mobile phone at least once a week during the last month?” “Have you ever used a step counter (pedometer) to monitor your steps during the past 12 months?” The participants were asked to select “yes” or “no.”

Statistical Analysis

Descriptive statistics were used to characterize the study sample at baseline and compliance with pedometer and mobile phone diary use. Bland and Altman plots were used to evaluate the degree of agreement between self-reported daily steps by mobile phone and pedometer measured daily steps by weeks.¹⁴ A random effect mixed linear method was used to examine whether the timing of mobile diary use changed over 3 weeks, and also whether steps reported by a mobile phone changed over the 3 weeks, accounting for the within-subject correlation. If participants did not use a mobile diary, the recorded time was considered missing and values were not inputted. All analyses were run using Stata 9.0 software (Stata Corp, College Station, TX).

Results

Sample Characteristics and Changes in Steps

In the sample, the mean age was 48.4 (SD $\pm$ 13.1) years; 58.5% were nonwhite; 60.9% graduated from college; 51.4% had never married and 24.2% were widowed or divorced; 51.2% had a full or part-time job; and 31.7% had less than \$20,000 annual household income; 80.5% had health insurance. Only 7.3% smoked at least 1 cigarette during the last week, 24.4% were on antidepressant medication, and 58.5% had a body mass index (BMI) > 30.0 kg/m². Only 9.8% used a pedometer during the last 12 months and 87.8% used a mobile phone at least once a week during the last month before study enrollment. In a mixed linear method, overall self-reported steps by mobile phone diary significantly increased each week: 5125 (95% CI: 4325 to 5925) in week 1 (baseline), 5822 (95%CI: 5020 to 6625) in week 2, and 6467 (95% CI: 5663 to 7272) in week 3 (the overall trend across the 3 weeks was significant $P < .001$).

Compliance With Pedometer Use and Mobile Phone Diary

During the 3-week study period, overall compliance with pedometer use was 93.8% (range from 52.4% to 100%). Approximately 71% ($n = 29$) of the subjects had 100% compliance with the pedometer. The self-reported reasons for low compliance were 1) not being able to locate the pedometer for several days, 2) forgot to put the pedometer back on after bathing or a nap, and 3) illness or having stayed in bed all day. Overall use of the mobile phone physical activity diary was 88.3% (range from 57.1% to 100%). Twenty-seven percent ($n = 11$) had 100% compliance with the diary. The self-reported reasons for low compliance were: 1) the downloaded physical activity program during the first visit was frozen and required to redownload the program; and 2) forgetting to open the diary between 7 PM and midnight. In a mixed liner method, the average timing of mobile diary use in week 1, 2 and 3 were at 9:26 PM (95% CI: 9:05 PM—9:47 PM), 9:31 PM (95% CI: 9:09 PM—9:52 PM), and 9:43 PM (95% CI: 9:21 PM—10:04 PM), respectively. The overall trend across 3 weeks was significant ($P = .006$).

Concordance Between Self-Reported Daily Steps by Mobile Phone and Pedometer-Measured Daily Steps in Sedentary Women (Bland Altman Plots)

Figures 1a, 1b, and 1c show Bland Altman plots of the difference between self-reported daily steps by mobile phone and pedometer-measured daily steps from week 1 to week 3. The overall agreement of the 2 measurements was high. The mean difference and 95% limits of agreement narrowed from week 1 to week 3. In week 1, the mean difference was -289 steps with a 95% limit of agreement at 2302 to 2880 (see Figure 1a). The number of steps reported by mobile phone tended to be lower than pedometer measured daily steps. However, in week 3, the mean difference between the 2 measurements became slightly positive ($+33$ with 95% limits of agreement: 1316–1250) (see Figure 1c). When participants were asked to increase number of steps from the week 1 and week 2 by 20%, 7.3% of (3 of 41) women consistently started to report a larger number of steps by mobile phone than pedometer measured daily steps.

Discussion

The present pilot study examined the compliance to wear the pedometer and record steps in a mobile phone based physical activity diary, and the concordance between self-reported daily steps in the mobile phone diary and pedometer readings. Overall, compliance rates for both pedometer use and use of the mobile phone diary were high, although women did not know that the pedometer was recording their total daily steps for the 3-week period. The compliance to using a mobile diary in this pilot study was similar to previous study findings.¹⁰ A recent systematic review reported that the average compliance to an electronic diary including a mobile phone diary was 83%.¹⁰ The majority of the reviewed studies using an electronic diary ranged between 1 week and 1 month. Shorter length of diary use, old age groups, alarm/ reminder functions, and manual/training how to use diary were predictors of high compliance in using an electronic diary. In contrast, it is somewhat difficult to compare our compliance in wearing a pedometer to other studies. Pedometers used in previous studies could only store one week's amount of data, so compliance with pedometer use

relied solely on self-reported measures, such as pencil and paper diaries. However, our compliance in wearing a pedometer was verified by stored data in a pedometer.

Our high compliance rates may be explained by the fact that the enrolled subjects were highly motivated and well acquainted with the requirements of the study. During the telephone screening process, we described to potential participants in detail what would be involved being in the study, including potential barriers to wearing a pedometer daily for 3 weeks (eg, type of clothing she could wear and still attach the pedometer). Second, during the training session, we informed the participants that their diary use and daily data would be monitored by a researcher every day. We also informed women that if they did not use the mobile phone diary consecutively for 3 days, they would receive a text message and/or a call from the research nurse. Third, we incorporated a reminder to notify the participants to complete the diary. Fourth, immediately after daily step entry, a bar graph with their past 7-day daily steps was displayed. Dependent on their daily step goal achievement, participants received a green, yellow, or red bar graph each night, followed by a short encouraging message. Providing a self-monitoring tool and immediate feedback in the mobile phone diary might increase the compliance in wearing a pedometer and in using a mobile phone diary. Lastly and most importantly, the combination of mobile phone diary and pedometer use might have worked together to reinforce each behavior, therefore increasing compliance of both measures.

As shown in Bland Altman Plots, the overall concordance between self-reported daily steps by mobile phone and pedometer-measured daily steps was relatively high from week 1 to week 3. However, a few findings from the Bland-Altman Plots need to be highlighted. In the first week, there was a trend for self-reported daily steps by mobile phone to be smaller than pedometer-measured steps. This trend could be associated with timing of diary data entry. We instructed women to use the diary right before they went to bed, but they might have used the diary soon after it became available (between 7 PM to midnight), before the end of their daily activities in the week 1. In weeks 2 and 3, the mean differences between the 2 measures became smaller compared with week 1.

In weeks 2 and 3, 7.3% (3 of 41) of women reported additional steps from their actual pedometer reading, when they were asked to increase their steps by 20% from the previous week. The disagreement (self-reported > pedometer measured steps) between the 2 measures could be related to social desirability bias (over-reporting “good” behavior), since this occurred when the average daily steps were approximately < 3000 steps. A recent systematic review reported that 7 out of the 8 pedometer studies concluded that self-reported physical activity levels were higher compared with the pedometer results.¹ The National Health and Nutrition Examination Survey 2003 to 2004 conducted the first study to provide new insights regarding discrepancies between self-report and objective measures of physical activity in a U.S. population based survey. Approximately 51% of the National Health and Nutrition Examination Survey 2003 to 2004 sample met the current guidelines of 150 minutes/week of moderate or greater activity, based on self-report of physical activity.¹⁵ However, only 5% of the adult sample met the current guidelines based on accelerometer measured physical activity. This striking difference between the self-reported and

objectively measured physical activity level could be explained by a combination of social desirability bias and recall bias.

In this pilot study, a relatively small proportion of women over-reported their step number. We do not know the mechanism of the high concordance between the self-reported and objectively measured steps. One of the potential reasons is that the mobile diary in this pilot study did not allow forward and backward filling of data, which could lead to a recall bias. Another reason could be that use of a mobile phone diary may reduce tendencies to engage in socially desirable responses. However, to our knowledge there has been no research on effects of the use of a mobile phone diary on social desirability. Given the growing number of research studies using a mobile phone diary, future research is warranted.

Strengths and Limitations of the Study

Our study had several strengths. First, to our knowledge, this is the first study to examine the concordance between self-reported daily steps by mobile phone diary and pedometer measured daily steps. Second, all 41 subjects completed the study (no drop out) and they were highly compliant with both the pedometer and diary. A few limitations should be taken into account when interpreting these findings. First, in this study, the subjects were limited to sedentary women who were willing to use a mobile phone and pedometer. The study findings might not be generalizable to other populations, such as sedentary men. In addition, the concordance was observed over a relatively short period. In general, the length of a physical intervention and maintenance phase are at least several months. Thus, the frequency of participants' over-reporting daily steps could increase at later times in the study, since the participants might not be able to reach an increased weekly goal.

Conclusions

The combination of a pedometer and a mobile phone diary may enhance the quality of the self-reported data in a clinical study.

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Figure 1.

(a) Bland Altman Plot of the difference between self-reported daily steps by mobile phone and pedometer measured daily steps in week 1. (b) Bland Altman Plot of the difference between self-reported daily steps by mobile phone and pedometer measured daily steps in week 2. (c) Bland Altman Plot of the difference between self-reported daily steps by mobile phone and pedometer measured daily steps in week 3.