Usability of a Home-Based Monitoring System for Community-Dwelling Elderly People during a Pilot Study

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***Abstract*— The aim of this pilot study was to evaluate the usability of a monitoring system that can monitor indicators of physical functioning (weight, balance, grip strength, and physical activity) in community-dwelling elderly people. Monitoring such indicators can identify elderly people who could benefit from (preventive) interventions. The system can also provide feedback to support elderly people in their self-management. A geriatrician invited patients aged 70 years or older to participate in the pilot study. Participants rated the usability of the monitoring system after using the system at home for three weeks. Usability was measured on a 7-point scale using an adapted version of the Post-Study System Usability Questionnaire and by logging errors that occurred in a diary. Six participants between 79 and 83 years old were included and four of them completed the pilot study. The mean usability score was 5.2 (SD .90) and scores ranged from 3.8 to 6.2. The participants were mostly positive about the usability of the monitoring system but some improvements have to be made before the system can be implemented and evaluated on a larger scale.**

Keywords-telemonitoring; physical functioning; usability; elderly people

I. INTRODUCTION

In community-dwelling elderly people decreases in indicators of physical functioning, for example weight, grip strength, balance, or physical activity, predict adverse health outcomes such as disability, hospitalization and nursing home admission [1-3]. If care professionals would be able to detect decline in physical functioning in their patients at an early stage, interventions could be provided to slow down or prevent (further) decline or adverse outcomes. Elderly people with a decreased level of physical functioning might be the ones who are most likely to benefit from such intervention programs.

Due to the increasing number of elderly people and the decreasing number of care professionals, it is not feasible for care professionals to assess physical functioning in all their patients on a regular basis using physical performance tests. As a result, elderly people and care professionals are often not aware of decreases in physical indicators at an early stage and decline continues until (health) problems arise [4]. Innovative technologies can play an important role in the early identification of decline in physical functioning. Such technologies are on the rise and are often used to support remote monitoring of health conditions, self-management, and the delivery of interventions [5, 6].

A monitoring and feedback system that can be used by elderly people to measure indicators of physical functioning on a daily basis was developed by engineers from the Université de Technology de Troyes (UTT) and researchers from Maastricht University (UM). The monitoring system consists of three devices: a bathroom scale for monitoring weight and balance, a grip ball for monitoring grip strength, and a mobile phone with a built-in accelerometer for monitoring physical activity [7-9]. The three devices are equipped with Bluetooth® so that the results of all the measurements are automatically transferred to the mobile phone. Via an application on the mobile phone, elderly people receive feedback regarding (changes in their) weight, balance, grip strength, and physical activity. Furthermore, the phone transfers the data to a database where health care professionals have access to the measurements that were performed by their patients. This enables care professionals to monitor the physical functioning of their patients from a distance and can help them in providing adequate and pro-active care. Figure 1 illustrates how the system works. Elderly people and care professionals can collaborate to determine realistic and personally relevant goals with regard to physical functioning. Self-monitoring of the indicators of physical functioning and collaboration with care professionals can support elderly people in their self-management [10-12].

The monitoring and feedback system can only reach its full potential when elderly people are able to use it in their daily lives. To optimize the system's usability it has been developed in close collaboration with elderly people and care professionals [13, 14]. During the user-centered development

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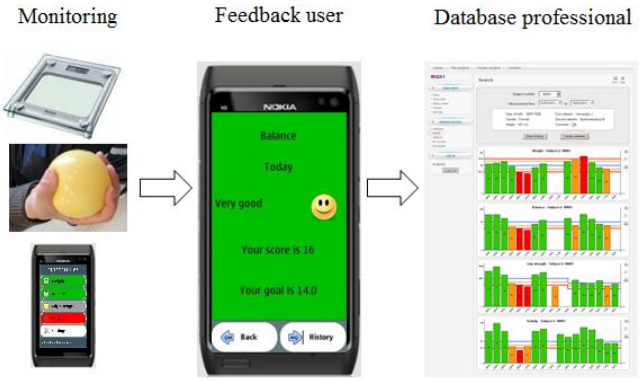

Figure 1. Monitoring and feedback system

process, the system was fine-tuned to the needs and requirements of the end users as much as possible. Taking human and other non-technology issues into consideration during the development process increases the usability and acceptability of the technology [15, 16]. The aim of this pilot study was to test the usability of the bathroom scale and the mobile phone in the daily lives of five elderly people. This small sample size was chosen because according to Nielsen et al. this should be sufficient to identify about 80% of the usability problems of a system [17]. The pilot study only focused on the usability of the system as experienced by elderly people and not on the usability of the database by health care professionals. Unfortunately the usability of the grip ball could not be tested yet due to problems in its production process.

This paper describes the methods that were used to study the usability of the monitoring system and presents preliminary results. The discussion will provide an interpretation of the results and an overview of the strengths and limitations of the study.

II. METHODS

The methods section describes the design of the study, the recruitement of participants, the study procedure, and the measurements and analyses that were used to study the usability of the monitoring system.

A. Participants and design

Participants were recruited via the expertise center for elderly care at the Orbis Medical Center in Sittard (the Netherlands). Inclusion criteria were: 70 years or older, community-dwelling, mobility or functioning problems, Mini Mental State Examination (MMSE) > 23, able to step onto a bathroom scale independently, and willing to learn how to use the interface on the mobile phone. Exclusion criteria were: planned admission to a nursing home/hospital during the period of the pilot study, being confined to bed, serious visual or hearing impairments, and contra-indication for exercise. The center's geriatrician invited eight patients who met the inclusion criteria. They received an information letter and a consent form via mail. Thereafter, the researcher contacted them within two weeks to ask whether they were willing to participate or whether they had questions regarding the pilot study. Patients who decided to participate signed written informed consent. Usability of the monitoring system (bathroom scale and mobile phone) was measured after three weeks follow-up. This study was approved by the Medical Ethical Committee Atrium-Orbis-Zuyd (NL35961.096.11).

B. Study procedure

At the start of the study the researcher (JV) visited each participant in their home. During that visit, instructions regarding the daily use of the bathroom scale and the mobile phone were provided to the participants. They also received two instruction manuals. The first manual was a simple overview of which steps they had to perform on a daily basis to monitor their own weight, balance, and activity. The second manual provided more detailed information about the two devices, using written text and photographs. Once instructions were provided, the participants practiced the use of the bathroom scale and mobile phone with the researcher until they felt confident in their ability to use the system. After that, the bathroom scale and mobile phone (+ charging hub) were installed in the homes of the participants at a place that was convenient for them.

After the home visit, the participants used the bathroom scale and mobile phone on a daily basis for 3 weeks to monitor their own weight, balance, and activity. Participants could use the bathroom scale between 7:00 and 10:30 A.M. They were encouraged to use the bathroom scale around the same time every day wearing similar clothing (and no shoes). After they used the bathroom scale they started their activity monitoring of that day. They did this by pressing the 'Start' button in the activity submenu of the application on the mobile phone and by wearing the mobile phone with them in their pocket. Participants were encouraged to end activity monitoring around the same time every day. Since elderly women do not always wear clothing with pockets, a belt was provided to them to which they could attach the mobile phone. They could wear this belt around their waist.

C. Measurements

After daily monitoring their balance, weight, and activity for three weeks the participants received a modified version of the Post Study System Usability Questionnaire (PSSUQ) [18]. Some items were removed from the PSSUQ because they were not applicable and some questions which focused on the usability of the separate devices were added. As a result, the items from the PSSUQ could be divided in three subscales: usability of the bathroom scale (5 items), usability of the mobile phone (10 items), and usability of the monitoring system as a whole (10 items). The participants rated each item on a scale from 1 to 7 (whether they totally disagreed, disagreed, disagreed a little, were neutral, agreed a little, agreed, or totally agreed). Besides that, free space was available after each question so that the participant could provide an explanation or clarification. Examples of the items were: 'I liked using the bathroom scale daily to measure my weight and balance', 'I needed a lot of help with

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using the mobile phone', 'I liked using the monitoring system', and 'Overall I am satisfied with the monitoring system'.

The participants also received an agenda at the beginning of the pilot study that they could use as a logbook. They were instructed to write down any difficulties they had with the devices on the day that it occurred. If the participants experienced any problems or had questions regarding the devices with the monitoring system, they could call the researcher for help. The researcher recorded the problems that occurred in a logbook as well.

Finally, adherence to the daily monitoring regimen was automatically registered by the mobile phone.

D. Analyses

The scores on the adapted version of the PSSUQ were analyzed quantitatively. Mean scores were calculated for the total PSSUQ and the three subscales of the PSSUQ per participant. Higher scores indicate better usability.

The data that participants provided in the free text space of the PSSUQ, the data that was recorded in the logbooks of the participants, and notes in the logbook of the researcher were analyzed qualitatively. All remarks, comments, and reported errors were structured per device and per function of the monitoring system.

Adherence rate to the daily monitoring regimen was calculated by counting the number of days that data on the three physical indicators (weight, balance, and activity) were saved on the mobile phone. This number was divided by the number of days that a participant was included.

III. RESULTS

The results section provides an overview of the characteristics of the users and how they rated the usability of the monitoring system. Furthermore, data regarding the adherence to the daily monitoring regimen is presented.

A. Characteristics of study participants

Six participants, two men and four women aged between 79 and 83 years, agreed to participate and provided written informed consent. All participants owned a mobile phone but they rarely used it. None of the participants had used a smartphone before. Of these six participants, four completed the pilot study. One female participant (participant 6) dropped out after two days because she was suddenly admitted to the hospital and therefore her data will be disregarded in this paper. Another female participant (participant 4) decided to stop participation after using the monitoring system for 6 days. She indicated that the main reason for her drop-out was that she did not feel supported by her husband in using the monitoring system. Despite her early drop-out, the participant filled out the adjusted version of the PSSUQ after 6 days of participation.

B. Usability scores of PSSUQ

The usability scores that the participants provided on the adapted version of the PSSUQ are presented in Figure 2.

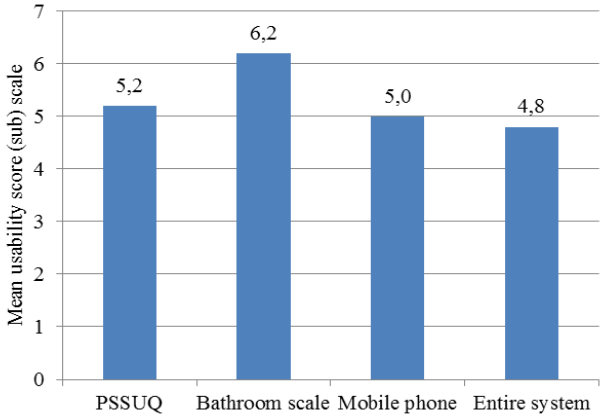

Figure 2. Mean usability scores after 3 weeks

The mean score on the adapted version of the PSSUQ was 5.2 (SD .90) and scores of participants varied between 6.2 and 3.8. The mean scores of the subscales for the bathroom scale, mobile phone and system as a whole were 6.2 (SD .64), 5.0 (SD .84), and 4.8 (SD 1.0) respectively on a scale from 1 to 7. The participant who dropped-out of the study after 6 days (participant 4) gave the lowest usability scores on all subscales.

C. Problems recorded in logbooks and PSSUQ

Analysis of the logbooks and comments on the PSSUQ revealed that some problems occurred with the data transmission of the bathroom scale. Participant 1, 2 and 3 all recorded in their logbook that the bathroom scale did not transfer the data to the mobile phone on one occasion. This made it difficult for the participants to continue with their activity measurement of that day. Besides that, the application on the mobile phone accidentally shut down on three occasions. Due to this error, which was reported twice by participant 1 and once by participant 5, participants had to restart the application before they could continue monitoring their weight, balance, and physical activity. Furthermore, participant 2 had difficulty with starting the daily activity measurement at the start of the pilot study. During an extra home visit it appeared that the participant kept pressing the stop button directly after pressing the start button.

D. Adherence to the daily monitoring regimen

Frequency calculations revealed that participant 1 did not monitor any of the physical indicators on 5 of the 21 days. Combining the logbook with the adherence data revealed that on all 5 occasions, the participant skipped the measurements because the visited family members on those days. Participants 2 and 3 monitored their weight, balance, and activity every day during the pilot study. No adherence rate was calculated for participant 4 because she dropped-out of the study. Participant 5 had the lowest adherence to the monitoring regimen since data of all three indicators were missing on 11 of the 21 days. Thus, the adherence rates of participant 1, 2, 3, and 5 were 76%, 100%, 100%, and 48% respectively. The adherence data from the four participants

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who completed the pilot study resulted in an overall adherence rate of 81% to the daily monitoring regimen.

IV. DISCUSSION

All participants who completed the study gave usability scores of 4 or higher on the different subscales of the adapted version of the PSSUQ and the participant who dropped-out rated the overall usability of the system with 3.8. This positive evaluation of usability is important since this is a prerequisite for the uptake of new technology in daily practice [15,16]. However, another important requirement that should be met is that the monitoring system should operate without interruptions [19]. Analyses of the logbooks that were kept by the participants and the researcher revealed that a few errors occurred during the pilot study and therefore some improvements are still needed in the monitoring system and the application.

The adherence of the participants to the monitoring regimen seemed to be satisfactory since three of the four participants used the bathroom scale and mobile phone at least 75% of the days to monitor weight, balance, and physical activity. Only participant 5 had low adherence, but this was mainly caused by the fact that the participant could not restart the application by herself after it had shut down automatically. So, her low adherence rate was a result of an error in the application that caused a usability problem.

A. Strengths and limitations

A recent review by van den Berg et al. regarding telemedicine and telecare for older patients revealed that the majority of studies in this field are carried out in 'younger older patients' who do not always represent the target group of the innovation [20]. A strength of this study is that the in- and exclusion criteria were formulated in such a way that the group of 'younger older patients' was not included. Another advantage is that the usability of the monitoring system was tested in the daily lives of elderly people instead of in a controlled lab-situation because this provides more accurate and detailed information regarding the usability problems that occur [21].

A limitation of this study is that only few patients participated which makes it difficult to draw a firm conclusion regarding usability based on the data that is available. Furthermore, the relation between the home measurements that were performed by the participants and medical outcomes was not studied. Therefore, no conclusion can be drawn yet regarding the usefulness of tracking health evolution of elderly patients and the possibility of detecting clinically relevant health changes with the monitoring system. During the pilot study some changes in weight, balance and activity were detected, but it is difficult to say whether these were clinically relevant or not. Besides that, small variations in weight might also have been caused by calibration issues that are often present in bathroom scales. But it is unlikely that these variations will lead to serious misinterpretation of weight recordings since participant use the bathroom scale every day which will average these variations.

Another limitation of this pilot study is that an adapted version of the PSSUQ was used to rate the usability of the monitoring system instead of the original version. This makes it difficult to compare the usability scores of this study to usability scores of other studies that used the original version of the PSSUQ. A positive aspect of the adapted version of the PSSUQ is that participants could provide comments to explain or complement their scores on each item. In combination with the logging files, this provided additional insight into what caused usability problems.

B. Conclusion and future work

The participants were mostly positive about the usability of the monitoring system but some improvements have to be made to the monitoring system and feedback application. The monitoring system and interface are currently being improved based on the results of the pilot study. Since the pilot study only had a few participants and a relatively short follow-up period, another study will be conducted during which 50 elderly people will use the improved system (including the grip ball) every day for 6 months. The follow-up study will not only focus on the usability of the improved monitoring and feedback system but also on the acceptability and added value as experienced by elderly people. Besides that, the usability, acceptability and added value of the system and database as experienced by health care professionals will be studied. We expect that the follow-up study will also provide more insight into the possibility of detecting clinically relevant changes with the devices of the monitoring system.

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