Motivating Older Adults to Exercise at Home: Suitability of a Humanoid Robot

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Abstract: Regular physical activity is a central protective factor for health. The promotion of physical activity is an important issue, especially for ageing societies, to achieve benefits of health and independence in old age. However, motivation for physical activity decreases with age. Due to staff shortages and high cost of personal exercise trainers, older adults living at home cannot be permanently motivated and instructed by health personnel to engage in physical activity. Several studies investigated the use of a humanoid robot as an exercise coach for older adults in nursing homes and laboratories, promising great potential. This explorative user study investigated whether a robot is a practical solution for older adults living in their own home and can motivate for regular physical activity in everyday life. Seven older adults participated in the study. In the study period of 12-14 weeks, they completed three different training conditions (instructions by a robot, a video instruction, and written instructions). Results showed that participants accepted and appreciated the robot, but most participants would not recommend the robot, mainly because several technical and other problems occurred. The present study showed that this humanoid robot is not suitable for autonomous exercise training for older adults at home.

1 INTRODUCTION

Due to demographic change, the proportion of older adults is rising in all industrialized nations (Vaupel, 2000). Health promotion and prevention are central issues for our society, especially for the older population, in order to be able to counteract the future increase in health costs due to illness and care costs.

One of the most important fields of action is the promotion of physical activity in old age (Weber et al., 2016). Regular physical activity is regarded as a central protective factor for health and is the measure that shows the most stable evidence of benefits in terms of health and independence in old age (Büla et al., 2014). However, physical activity is age-dependent and motivation for physical activity decreases with age (Scholes and Mindell, 2012). Therfore, many older adults don't move enough (Krug et al., 2013; Weber et al., 2016). The decrease in physical activity with increasing age (Bornschlegl, Fischer and Petermann, 2016) inevitably leads to a reduction in (functional) everyday abilities (Voelcker-Rehage, Godde and Staudinger, 2006), to losses in health, self-confidence, self-efficacy, participation in social life, cognitive abilities and to loneliness (e.g. Bornschlegl et al., 2016; Füzéki and Banzer, 2017; Gunzelmann, Brähler, Hessel and Brähler, 1999). There are many studies that show that targeted physical training can reduce frailty (e.g. Löllgen and Leyk, 2012) and thus increase quality of life and independence (e.g. Dorner and Schindler, 2017). Furthermore, regular physical activity reduces the occurrence of falls (Müller, Lautenschläger and Voigt-Radloff, 2016; Sherrington et al., 2016) and has positive effects on other physical complaints (Gadde, Kharrazi, Patel and MacDorman, 2011). Therefore, there is a high need for healthcare systems to develop effective solutions to ensure the physical wellbeing of older adults (Čaić, Avelino, Mahr, Odekerken-Schröder and Bernardino, 2019).

Although information campaigns try to make older adults aware of the benefits of physical activity, and various exercise programs promoting physical activity specifically for older adults exist, it cannot be

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guaranteed that older adults integrate physical activity into their daily lives. For this, it is helpful for physical activities to be prompted and guided regularly (Lebedeva et al., 2015). Regular guided training is more effective than unguided training (Gschwind and Pfenninger, 2016), and exercise programmes are beneficial only when followed regularly and over a long period of time (Gadde et al., 2011).

Due to staff shortages (World Health Organization, 2015) and the high cost of personal exercise trainers, older adults living at home cannot permanently be motivated and instructed by health personnel. Robot-guided training could enable older adults to exercise without a human coach and thus alleviate this situation and increase the motivation of older adults to carry out movement programmes in everyday life.

Several studies investigated the use of a robot as an exercise coach for older adults. Besides counteracting the future lack of healthcare staff, a robotic fitness coach could comply with the preferences of older adults. It has been shown that socially assistive robots can positively influence motivation (Torta, Oberzaucher, Werner, Cuijpers and Juola, 2013) and that a robot can be very motivating for seniors to perform physical activity and might be less boring for seniors than just performing an exercise session on their own (Werner, Werner and Oberzaucher, 2013b). In their study, Shen and Wu (2016) found a strong preference for a robotic instructor for physical exercise over a human instructor. Regarding motivation, it was shown that a humanoid robot instructor was experienced as very motivating and more motivating than a standard training plan, but not more motivating than a human trainer (Werner, Krainer, Oberzaucher and Werner, 2013a). For example, older adults of a day care centre were able to exercise successfully with the help of a robot (Görer, Salah and Akın, 2017). It was shown that a humanoid robot assisting in a demonstration, attracts onlookers and encourages them to participate in health exercises (Matsusaka, Fujii, Okano and Hara, 2009). Lewis, Metzler and Cook (2019) investigated a humanoid robot in a senior living community with older adults, caregivers and administrative staff. They focused on technical components as well as on affective reactions and opinions recorded in focus groups. Fasola and Mataric (2013) found that older adults prefer a physically embodied robot and a robot which creates a relation for example through praise (2012). Inpatients in an assisted living facility adjusted their movements to a humanoid robot used in geriatric physiotherapy rehabilitation (López Recio, Márquez Segura, Márquez Segura and Waern, 2013). Although technical malfunctions can influence acceptance parameters (Werner et al., 2013b), even incomplete prototype systems generated very positive responses (Gadde et al., 2011). It has been shown that performing exercises with a humanoid robotic partner exercising along with the participant boosted the effort compared to performing these exercises alone (Schneider and Kümmert, 2016).

Taken together, several studies indicate the great potential of humanoid robots as instructors and motivators for physical exercise for older adults. However, the question of the use of a humanoid robot as a fitness coach in the private households, where older adults must perform physical exercises independently with the robot, is still pending.

Our explorative user study investigated whether the implementation of a robotic training coach is a practical and motivating solution to promote regular physical activity of older adults living at home. The results show problems and motivating effects. This research can help to determine ways to support physical activity amongst older adults.

2 METHODS

2.1 Material

For this study, an exercise program was compiled based on "Walk safely, stand safely", a program recommended by Pro Senectute Switzerland for older adults (www.sichergehen.ch). Three strength exercises and three balance exercises were selected. The six exercises were presented in three versions based on the official video of the Swiss campaign. Firstly, a booklet with written instructions and pictures of the exercises, secondly, a video tutorial, and thirdly, a programmed humanoid robot (NAO V6, 6th version) acting as an autonomous exercise coach. The duration of the exercise program including an introduction and six exercises with verbal instructions was 36 minutes (for details on the selection process, programming, and pretest see Brack, 2019).

A self-developed questionnaire was used. Sociodemographic data collected were age, gender, marital status, type of housing, former professional activities, level of education, and residential area. Health status was measured with a single item “In general, would you say your health is… (ranging from “excellent” to “poor”) from the Short Form Health Survey (SF-36) (Ware, 2000). To collect the current physical activity of the participants three self-developed questions were asked “How often a week do you exercise?”, “How long does such a session usually last?”, “Do you do the activities in a group or alone?”.

To measure self-efficacy, the “Allgemeine Selbstwirksamkeit Kurzskala” (ASKU) (Beierlein, Kovaleva, Kemper and Rammstedt, 2012) was used with three items, and a five-point Likert scale from “not true at all” to “absolutely true”. Participant’s technical affinity was measured with two adopted questions (Seifert and Meidert, 2018) to be comparable within the Swiss population.

To evaluate the suitability of the robot NAO as an exercise coach in older adults’ homes, eight questions (see table 2) based on studies that equally evaluated a robot as an exercise coach (Fasola and Mataric, 2011, 2012, 2013; Torta et al., 2013; Werner et al., 2013a, 2013b), were compiled using an answer format of a five-point Likert scale from 1 “not at all” to 5 “very much”. Because of the explorative character of the study and the limited number of participants, qualitative methods were used. They make it possible to identify important issues and help understand subjective opinions of participants more in-depth (Misoch, 2015). A qualitative semi-structured interview was conducted with the following questions at the end of the study: (1) Were you able to train regularly (3 times a week) with the robot NAO? (2) Were there any difficulties during training? What didn't work? (3) Was it fun to train with the robot? (4) Was it motivating for you to train with the robot NAO? (5) How was the operation of the robot for you? Were there any difficulties? (6) If you look at your own experiences, do you think the use of NAO for older adults to activate movement is generally possible? (7) Would you like to tell us anything else about your experience with the robot?

2.2 Study Population

Eight older adults were enrolled in the study. Inclusion criteria were age over 65 years, no physical or cognitive restrictions which could impair the movement training, living in Switzerland and German-speaking, living in private homes. The older adults were recruited via the network of senior citizens of the institute.

2.3 Design and Procedure

The entire study period of this explorative user study was June 2019 to December 2019. In this period, the individual participants remained under study condition for 12-14 weeks.

The study started with an individual appointment for each participant at the study center (I): After informed consent and a pre-survey (T0), the participants were extensively introduced to all three conditions, and participated in a one-time training with the robot to get used to the handling, commands, etc. (see figure 1). The participants were instructed not to place the robot on a table or other elevation due to its instability in order to avoid a fall and thus damage to the robot. After this, the participants were interviewed using a questionnaire and semi-structured interview questions (T1).

Figure 1: Older adult trains with robot in the study center. Image source: Brack, 2019.

Independently at home, each participant then carried out a training including the three versions of instruction (written (Condition Booklet; C_B), video (Condition Video; C_V), robot (Condition Robot; C_R)) according to a predetermined schedule. In each condition, the participants remained one week and had to perform the six movement exercises three times under the respective guidance during this period. For each condition, they fulfilled a study protocol. Between each training week there was a break (B) of two weeks in which the participants were encouraged not to carry out the study exercises (see figure 2). After training with the robot, a face-to-face interview was conducted with the participants at home (T2). Two weeks after finishing the last training, a final telephone interview was conducted with each participant (T3) (see table 1).

In order to avoid effects that could occur due to the order of the three conditions, the sequence in which the study participants went through the three conditions varied. As only one robot was available for the study, the participants did not all go through the conditions in parallel but staggered in time. Due to a technical failure of the robot it was not possible to realize the same distance between the conditions for all participants, the repair lasting longer than three weeks.

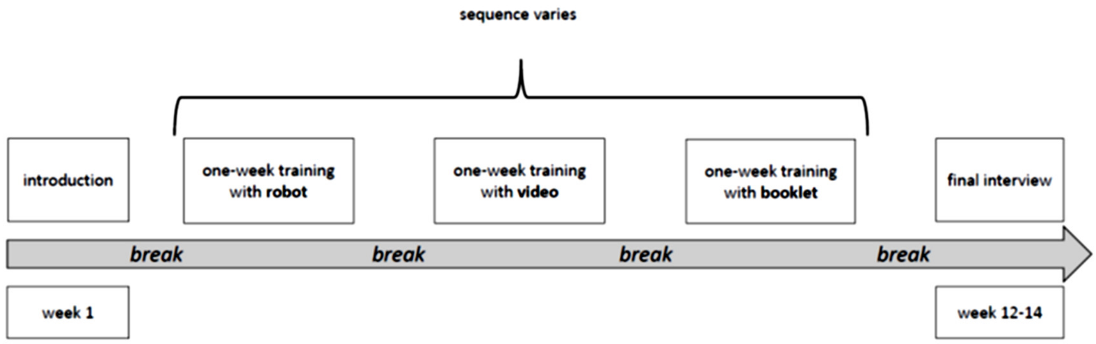

Figure 2: Course of the study conditions.

2.4 Analyses

Quantitative data from questionnaires were entered in IBM SPSS 26. Descriptive statistics (mean, standard deviation, frequencies) were used to characterize the sample and evaluate frequencies of the questionnaire answers. The Wilcoxon signed-rank test (Higgins, 2004) was used to compare motivation to train with the robot at the introduction and after a one-week training, as non-parametric tests do not require a normal distribution of data and are applicable to small sample sizes.

The statements of the participants in the semi-structured interviews (T2, T3), were collected based on written protocols and are summarized and reported. Due to small sample size and the explorative character of the study, no further qualitative content analysis (Mayring, 2000) was worked out.

3 RESULTS

3.1 Participants

Seven older adults participated in the study (P1-P4, P6-P8), five men and two women. One study participant could not participate in the study due to acute physical impairments (P5). The average age of the participants was 74 years (SD=5.63, Range 67-84). All participants were Swiss coming from three different cantons. Five participants described their current residential area as more rural, two as more urban. One participant described his general state of health as excellent, four as very good and two as good. Five participants had received up to tertiary level education and five participants lived in a household consisting of two persons. All participants said that they were very interested in new technical objects, and four participants considered themselves to be very interested, three as interested in technology. Two participants already had contact with a robot before at home, one at work, one somewhere else, and three participants never had contact with a robot before.

3.2 The Robot as a Training Coach

3.2.1 Experiences

- The participants could all perform the exercises with the robot.
- The appearance of the robot was perceived as pleasant.
- The joy of technology and the experience of something interesting and new was emphasized.

3.2.2 Barriers and Difficulties

Several difficulties in using the robot were reported by the participants:

Technical:

- It took a long time for the robot to get started.
- The participants had to wait too long to communicate with the robot, as it takes a long time for the robot to be operational, and the robot didn't react to instructions immediately.
- The older adults had to bend down towards the robot because the robot didn't recognize them.
- The robot didn't recognize the face of the older adults very well and was therefore not ready to take orders.
- The robot fell backwards while showing the exercises with six participants.

Acoustic communication problems:

- Computer voice was not optimally understandable.
- Sometimes the voice was perceived as strenuous.

Table 1: Survey dates and instruments.

Survey date	Duration (approx.)	Instruments, data
I: Introduction at the study centre	60-90 minutes	Informed consent, detailed introduction to the three conditions (booklet, video, robot)
(Part of introduction) T0*: face-to face interview and questionnaire at the study centre* before introduction to the conditions	15 minutes	Sociodemographic, question about physical training, state of health, self-efficacy
(Part of introduction) T1: *face-to face interview and questionnaire at the study centre* after introduction and first training with the humanoid robot	15 minutes	Self-developed scale robot as fitness coach
T2: *face-to face interview at participant's home* after the one-week training with the robot	30 minutes	Self-developed scale NAO as fitness coach, semi structured interview including questions of operation of the robot, problems during training, motivation
T3: *final interview by telephone* at least two weeks after the end of all three conditions	15 minutes	Semi-structured interview: state of health, suitability of the robot, problems, questions about motivation, experience, recommendations

General:

- There were too many and too long breaks in between exercises and the older adults didn't know whether the robot was not working, or if it was an intended break.

3.2.3 Motivational Ability

- The older adults found the training interesting, exercises attractive and the robot motivating for physical activity.
- Participants suspect that habituation effects occur when using the robot for a longer time.
- The vocal instructions were too long and should be individually controllable because it was boring for the older adults when the robot always gave the exact same instructions.

A significant influence of the one-week training with the robot on the evaluation of the robot as an exercise coach could not be proven using the self-developed scale. Wilcoxon-tests show no significant results (see table 2).

3.2.4 Recommendations of the Participants

- After the study the participants recommended the robot to be individually adaptable and personalizable.
- It has been mentioned that the social aspect of activities is missing, and this is very important especially for older adults.
- Participants wished for a robot bigger in size, so bending down to talk to it would not be necessary.
- A memory function, and variation in the programme and sentence structures was also requested.
- Announcing break durations and correcting false movements like a gym teacher were also suggested.
- In addition, the participants wished for the instructions of the robot to be compatible with hearing aids of older adults and requested the communication with the robot be easier and fully functional.

4 DISCUSSION

The older adults who trained with the robot considered the use of a robot at home to motivate them to do more physical activity. However, the used robot was judged as not suitable because of its abilities and the strict sequence of the programmed movement exercises. Further, the participants thought robot instructed training could be useful for people who are not yet physically active, but not for already active people.

Overall, after the study, the participants would not recommend the robot for exercise for older adults at home as they tested it, due to the problems mentioned above. A possible assignment for the robot was rather seen as the accompaniment of a human coach. In their study Čaić et al. (2019) conclude that a robotic coach can be used to motivate seniors to be more active, but human caregivers should make sure the elderly users perform the exercises correctly and assist them if necessary.

Table 2: Change in the assessment of the robot.

Question	T1 M (SD)	T2 M (SD)	Wilcoxon-test, exact significance, one-sided
How much did you enjoy training with NAO?	4.0 (0.82)	4.43 (0.98)	Z = -.828, p = .281, n = 7
Would you recommend NAO as a training coach to your friends?	2.17 (1.60)	2.50 (1.64)	Z = .000, p = .750, n = 6
How much would you like to train with NAO in the future?	3.14 (1.46)	2.29 (1.38)	Z = -1.857, p = .063, n = 7
Do you find NAO a good training coach?	3.43 (1.40)	2.71 (1.60)	Z = -1.089, p = .188, n = 7
How well could NAO motivate you for the training?	4.00 (1.41)	4.00 (1.73)	Z = -.378, p = .500, n = 7
Do you think NAO is more motivating than a human training coach?	1.43 (0.79)	1.29 (0.49)	Z = -1.000, p = .500, n = 7
Do you think NAO is more motivating than a training plan with video instructions?	3.57 (1.27)	2.57 (1.40)	Z = -1.382, p = .109, n = 7
Do you think NAO is more motivating than a written training plan?	4.71 (0.49)	3.57 (1.62)	Z = -1.857, p = .063, n = 7

The written instructions based on the booklet were by all participants considered to be the least motivating. The video condition was judged best.

During the one-week training, the participants experienced the limitations of the robot (technical problems, inflexibility, rigidity in repetitions, no personal approach to the participants) as an obstacle for further use. The participants would not recommend the robot to other older adults, and if, then with restrictions. Much would have to be technically changed and adapted, and the question of cost-benefit arises.

As stated in the semi-structured interviews, the robot's motivational factor quickly diminished when the novelty effect was exhausted. The effect that users engage easily in interactions with new technologies, but their interest in continuous usage decreases rapidly after a novelty effect vanishes is widely observed (Rosenthal-von der Pütten et al., 2014).

5 CONCLUSIONS

The programmed humanoid robot was accepted and was appreciated by the study participants. However, most of the participants would not recommend the robot for use for older adults at home, and if so, only with limitations. The pilot study showed that the programmed robot is not suitable for autonomous exercise training for older adults at home. These statements given by older participants who were highly motivated and interested in technology should be taken very seriously.

Some limitations of the study should be noted. The study was explorative in order to find out what problems can occur when implementing a robot as a motivator for training. It was not examined whether the physical fitness of the participants changed. Due to the high demands on the participants (12-14 weeks in study condition, several visits at home, etc.) and the fact that only one robot was available, only seven participants were included in the study. The sample is small and therefore has a limited representativeness, especially the meaningfulness of statistical evaluations of quantitative data gathered in this study is restricted.

Real life testing had some challenges: due to technical problems of the robot and personal appointments of the participants, not all of them went through the study in the same time, and variation of the three conditions could not be balanced in this group.

It should also be stated that humans, not robots, were depicted in the booklet and the video instructions. In addition, the robot praised the participants at irregular intervals during the training. The influence of this reinforcer was not examined.

Regarding the positive evaluations, it must be considered that the participants are a highly selective group. They were quite interested in technical solutions and willing to participate in such a study. Therefore, it must be assumed that it is very likely to generate positive evaluations. These should not be transferred to other groups or the general population.

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