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Experiences of a Humanoid Robot-Led Physical Training Program for Home-Living Older Persons - A Qualitative Pilot Study

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Abstract
Maintaining good physical condition throughout life might reduce the risk of disease and improve older persons' physical and mental health. Several positive outcomes in the care of home-living older persons have been linked to technological solutions such as humanoid robots. The aim of this study was to develop a humanoid robot-led physical exercise training program for home-living older persons and to explore eleven home-living older persons' experiences of the program. Semi-structured interviews was held with the home-living older persons after their testing the program and transcribed interviews were analyzed by thematic analysis. The home-living older persons experienced the program as easy to follow and that the program might improve their mental well-being and social interactions. To positively influence older persons' physical condition, more person-centered exercises and a more suitable robot should be included. Further development of humanoid robot-led physical exercise training programs is needed to ensure the usability of a similar programs in the context of older persons.

Keywords Older persons · Home-living · Humanoid robot · Physical training

1 Introduction

The majority of older persons want to continue living in their own homes and familiar surroundings as they age. Healthcare services is therefore increasingly being offered in older persons' own homes [1]. This is a challenge for both care professionals and society because the quality of care given in a person's home should be equal to care given elsewhere [2]. In addition, demand for homecare services has increased, linked to the growing number of older persons and the shortage of care professionals [3]. Technological advances have made it possible to provide complex care in home settings [4]. Humanoid robots are more and more often being considered as a solution to the above-mentioned challenges currently seen in healthcare [5]. Briefly, a humanoid robot is a robot with human-like features [6] and is generally defined as a programmable machine that can imitate human actions [7]. Nao and Pepper by SoftBank Robotics, Palro by Fujisoft, or Care-O-bot by Fraunhofer are examples of some humanoid robots currently used in healthcare.

Earlier studies reveal the widespread use and benefits of humanoid robots as exercise trainers in the care of older persons. Melkas et al. [8] studied the impact of humanoid robot use with older people in a municipal elderly care setting. They found that using a humanoid robot for rehabilitation activities with older persons was associated with a positive impact on activity and interactions. This was interpreted as older persons perceiving the robot to be more of a guide to follow than a companion to walk with. Zuschnegg et al. [9] examined the expectations regarding the support of (psychosocial and physical) needs of humans by humanoid social assistive robots in dementia care and stated that the robots could offer potential support in e.g., mobility/ body posture by giving instructions for physical exercise. Torta et al. [10] examined the use of humanoid robots in providing

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entertainment for older persons. This included, among other things, the facilitation of physical exercise programs, for which they found that older persons trusted the robot. They also saw that older persons did not feel anxious when using the robot because of its small size and shape. Andtfolk et al. [11] showed in a scoping review that the use of humanoid robots for cognitive training or for providing interaction for older persons were much more researched than the use of robots for physical training.

Previous studies also reveal some barriers of using humanoid robots as exercise trainers in the care of older persons. Ishiguro et al. [12] studied both older persons' and caregivers' perceptions of humanoid robots with respect to patient education advice, using a robot that, e.g., walked with older persons. This study revealed that learning effect could fade if implemented applications of the robot did not change. Piezzo and Suzuki [13] investigated the use of a humanoid robot as a walking trainer for older persons. They saw that even if older persons could follow the pace of the robot and did not perceive walking with it to be dangerous that most nonetheless chose to walk behind the robot instead of side-by-side, and the conclusion was made that the humanoid robot was more of a guide than a companion to walk with.

Lehto and Rantanen [14] studied homecare workers' perceptions of how humanoid robots can be used to support older persons in homecare settings, with the aim to reveal how care professionals' work in such settings can be improved through the introduction of robotic innovations. Both strengths and weaknesses were revealed, with the homecare workers perceiving that the robots could reduce clients' loneliness, provide clients with physical assistance and facilitate rehabilitation, improve clients' safety and ease clients' activities of daily living. However, the homecare workers also believed that humanoid robots could intimidate clients and that the use of such robots in client homes could be challenging because of the diversity of clients' physical home settings.

Most earlier studies on the use of humanoid robots within healthcare settings have either been undertaken in nursing home settings [13, 14], in home-like environments [15, 16] or in laboratories [17, 18], but generally these robots are not yet commonly commercially available. There are few studies on the use of such robots with home-living older persons or studies on humanoid robots facilitating physical exercise for older persons. The World Health Organization [19] finds that maintaining good health behaviors throughout life, e.g., physical exercise, might reduce the risk of disease and improve both physical and mental condition. The aim of this study was therefore to investigate home-living older persons' experiences of a humanoid robot-led physical training program (PTP). Research questions: (1) What are the home-living older persons' experiences of the humanoid robot-led PTP? (2) What are the home-living older persons' recommendations for further improvement of the humanoid robot-led PTP?

2 Materials and methods

This study had a qualitative pilot design intended for a full-scale investigation. The study was performed in compliance with the ethical principles delineated by the Finnish National Board on Research Integrity TENK [20]. Ethics approval was obtained from the University's Ethics Committee. All participants provided written and verbal informed consent for participation and were given information about their right to withdraw for any reason, without penalty. In addition, ethical approval directly from the assisted living facility involved in the study prior to its commencement. This step was integral to ensuring compliance with ethical standards and safeguarding the well-being of the participants. No material was either tape-recorded or filmed.

2.1 Context and Sampling

The study was carried out at an assisted living facility in Ostrobothnia, Finland. The assisted living facility offers organized leisure and entertainments such as events/activities. On-site healthcare facilities are also available, including hospital services and care centers. Data was collected from February to March 2020. Home-living older persons were invited by letter to participate. The letters were distributed through the assisted living facility setting included in the study. Staff at the assisted living facility distributed letters to clients and granted the researchers the opportunity to incorporate the advertisement into their newsletter and post announcements.

Inclusion criteria included being 65 years or older and living independently at home while participating in events/activities offered at the assisted living facility. Bedridden older persons and those with cognitive disorders affecting memory were excluded.

2.2 The Robot

In this study, the humanoid robot Nao developed by SoftBank Robotics (Paris, France) was used. Fifty-seven cm tall and weighing 4.3 kg, the aim of Nao is to provide cognitive, physical and social support for the user. It has a human body structure with functions of environmental perception and vision. In addition, it has several features that allow it to interact, perceive and move. It was designed to be user-friendly, featuring a spacious touch-screen and mobility.

However, during this particular study, the humanoid robot remained stationary due to challenges in moving on thick carpeting. The decision of using Nao was because of the robot's humanoid design, with anthropomorphic features and expressive capabilities, facilitates natural and intuitive interactions with users of all ages. In addition, Nao is renowned for its robustness, reliability, and safety features, making it well-suited for deployment in real-world settings such as homes or community centers where older adults reside or congregate (Softbanks Robotics). Therefore, Nao was considered to be suitable for leading a PTP for home-living older persons.

For this pilot study, a workshop was held in December 2019 with the aim to identifying and defining appropriate exercises of physical training programs offered to home-living older persons. Attending the workshop were some of this study's researchers ($N=2$) and independent physiotherapists ($N=3$). The physiotherapists were considered suitable for inclusion in the design process, because they had professional knowledge of home-living older persons' needs regarding physical condition and training routines. During the workshop, participants were answering questions toward i.e. an average home-living older person's health condition or an appropriate PTP for a home-living older persons.

When designing the humanoid robot-led PTP, taken into account were the feedback from physiotherapists, the humanoid robot's natural functions (e.g., capacity to reset body positions) and the chosen software's visual programming capacities. By linking several of the humanoid robot's natural functions and exercises one after the other, an advanced program flow was created that allowed the robot to act and interact in a complex way. Using the Kiosk individual user interface part of the ZBOS software, the humanoid robot-led training program was customized regarding intuitive interaction (e.g., speech recognition and engine in the Swedish language, perception modules for recognition of approaching interaction partner, body language, speed functions, Light Emitting Diodes and microphone for multimodal interaction, music per session).

The humanoid robot-led PTP was built stepwise and included three four-minute exercise sets, for a total of 12 min altogether. The training program started with the humanoid robot leading a warm-up mainly stretching arms, neck and back. The humanoid robot continued with various upper body exercises (five repetitions per exercise) e.g., stretches, head rotations, upper body rotations, arm exercises, touching feet or knees with hands. The humanoid robot ended with easier ("cool down") stretches (Table 1).

Table 1 Setup of the humanoid robot-led PTP

Exercise	Function	Length
Warm-up	Stretching arms, neck and back	4 min
Upper body exercises	Stretches, head rotations, upper body rotations, arm exercises, touching feet with hands, touching knees with hands	4 min
"Cool-down"	Stretching arms, neck and back	4 min

2.3 Data Collection Procedures

A group of home-living older persons ($N=11$) of varying gender, age and health condition met during February and March 2020 to test the humanoid robot-led PTP at the assisted living facility. The older persons' ages ranged from 72 to 86 years and eight were female. All lived independently at home and had various health conditions that affected their physical needs. For example, some could drive themselves to the study setting while others arrived by taxi; some could walk unaided while others used walking aids (walker, cane). Although the older persons lived in own homes, they were known to each other, having previously participated together in activities at the same assisted living facility setting.

The testing phases consisted of two humanoid robot-led PTP sessions together with all 11 home-living older persons at the assisted living facility setting. The older persons were asked to freely interact with the humanoid robot both before and after each PTP session but were kindly asked to remain seated in their respective chairs during a session and follow the exercises to the best of their ability. The PTP included three four-minute exercise sets, for a total of 12 min altogether. To ensure safety, the humanoid robot was used only under appropriate and competent researcher control and supervision. The researcher's role was to start each PTP session by activating the robot as well as to offer support regarding the humanoid robot use, research topic and approach.

Initially, the inclusion of a larger end-user participant cohort and a total of three once-weekly PTP sessions were planned. However, the ongoing COVID-19 pandemic disrupted such plans. A larger group (of vulnerable, older persons) was considered to constitute a risk, and only two once-weekly PTP sessions were completed before the recommendation was given that persons aged 70 or older living in Finland should self-isolate. Consequently, the third intended once-weekly PTP session was not held as planned. After having participated in the second, and last, once-weekly PTP session, those home-living older persons who had participated in both sessions were interviewed, about a week after the last PTP session in March 2020.

By involving the older persons in semi-structured interviews, the aim was to delve deeper into their subjective experiences and perceptions of the intervention, including its impact on their physical condition, mental well-being

Table 2 Examples of the interview questions used during the semi-structured telephone interviews

1. How did you experience your participation in the humanoid robot-led PTP?
2. What factors do you think affected your evaluation of the program?
3. How has the program affected you?
4. In your opinion, what opportunities are there for using a humanoid robot to lead PTP?
5. In your opinion, what are the challenges associated with using a humanoid robot to lead PTP?
6. What are your recommendations for the further improvement of the program?

and social interactions. This depth of understanding was considered essential to elucidate the mechanisms underlying the observed outcomes and to gain insight into the factors that may have contributed to the study findings. These individual semi-structured interviews lasted between 25 and 70 min each and were held by telephony to ensure participant safety. The interviews were conducted by the first author (NN) and were recorded and transcribed into written form. The material consisted of 88 pages transcribed text (Times New Roman, 12 p, single space). The interview topics were based on specific aspects of the current experiment. Topics were related to the older persons' experiences of the humanoid robot-led PTP (e.g., format, exercises, functions, factors that influenced one's evaluation, opportunities, challenges, benefits, recommendations), all with the aim to address the usability of the program. See examples of the interview questions in Table 2.

2.4 Analysis

The transcribed interviews from Phase 3 were analyzed by thematic analysis in the process of identifying themes or patterns within the qualitative data analysis [21]. Thematic analysis was chosen as the analytical method for the study's semi-structured interviews due to its flexibility, inductive nature, holistic approach, methodological rigor, and accessibility. Braun and Clarke's [21] 6-step framework has been followed, as it offers a clear framework for doing thematic analysis. Two of the authors participated in and contributed to the data analysis (NN, NN). The 6-step framework used in this study included: Step 1: Become familiar with the data, Step 2: Generate initial codes, Step 3: Search for themes, Step 4: Review themes, Step 5: Define themes, and Step 6: Write-up. Step 1 was reading and re-reading the transcribed interviews. Step 2 started to organize the data in a meaningful and systematic way to address the research questions. Step 3 examined the codes into preliminary themes. Step 4 included a review, modification and a development of the preliminary themes. Step 5 included a final refinement of the themes and Step 6 is shown in this study's result section and discussion section. During all steps of analysis, the two authors highlighted variables such as participant's physical status, cultural background, age and gender to understand and interpret the data. Through the analysis, semantic themes were searched for according to Braun and Clark [21]; "...within the explicit or surface meanings of the data and the analyst is not looking for anything beyond what a participant has said or what has been written".

3 Results

Four overarching themes emerged related the home-living older persons' experiences and recommendations for further improvement of the humanoid robot-led PTP. These included: (1) acceptance of the robot, (2) value of exercises, (3) companionship, (4) recommendations for improvement.

3.1 Acceptance of the Robot

The majority of older persons experienced the humanoid robot leading the PTP as being both enjoyable and fun. However, there were many concerns about the humanoid robot's inability to lift weights or heavier things. Some thought the size of the robot was appropriate because it was not intimidating, while others thought it was too small for its intended purpose. The use of a small humanoid robot for group physical training was considered a challenge, e.g., some participants sitting further away had difficulties seeing the robot/exercises. In addition, many older persons perceived that the use of humanoid robots in homecare would not be cost effective, referring to the study robot's cost and narrow range of functions.

> "It looked like a Lego man, with the shape of its head. It doesn't arouse any fears, but you were happy to see it". (P7)

> "It's not for me at the moment. I don't need anything like that. I don't know what I would use it for". (P4)

4 Value of Exercises

The home-living older persons had both positive and negative experiences of the humanoid robot-led PTP. They perceived the exercises to be easy to follow and familiar. They mentioned that the exercises were enjoyable and fun, especially those where several body parts were used simultaneously. However, the most common negative experience was that the program did not include sufficiently challenging

exercises. All but one of the older persons maintained that the exercises were too easy and stated that other home-living older persons would neither find the exercises useful nor motivating over a longer period of time. Moreover, some stated that they would rather do the exercises without a robot, because they did not consider the program in its current form to be useful for those older persons in better physical condition.

> "As long as you can manage to live at home, you have to stay in good physical condition and need more challenging exercises". (P3)

The older persons' comments on participating in the humanoid robot-led PTP were all quite similar. The majority stated that they would choose other daily activities over the program in its current form. Nevertheless, the majority also expressed feelings of higher mental well-being while participating in a PTP session. Although many mentioned that they were doubtful before the first session, after one session they noted that the PTP sessions was fun and perceived that they were in a better mental mood. Some mentioned that they felt better after the second session rather than the first one because they were more relaxed. The older persons also believed that their participation in a humanoid robot-led PTP could become habitual after a while. Some highlighted that the program gave variety to their everyday life and thereby improved their mental well-being. Only a few mentioned that they experienced physical well-being during the PTP sessions, yet upon further questioning they could not describe exactly why they felt this way.

> "I was happy to participate… somehow, you got in a good mood". (P2)

> "During the training I forgot my pain and everything around… but instead lived in the movements". (P1)

5 Companionship

Many thought the humanoid robot-led PTP could increase their social interactions. Many furthermore mentioned that social interaction during PTP sessions was important because they did not want to be left alone with the humanoid robot. There were also comments on how the program could facilitate the sharing of thoughts and experiences with strangers. There were even comments on the positive aspects of experiencing something new like a humanoid robot-led PTP program. Some even highlighted they would not have participated if not for the opportunity to meet the robot.

> "Not alone with the robot, but in a place with other [persons] so I can be social with them". (P11)

> "I felt [like I was] chosen to meet the robot". (P7)

Also, many older persons perceived that the use of humanoid robots in homecare would not be cost effective, referring to the study robot's cost and narrow range of functions. Although the older persons expressed awareness of ongoing societal challenges linked to the lack of care professionals for older persons, the majority emphasized that robots could not replace human trainers in PTP programs, noting the importance of human empathy.

> "[The robot] cannot replace a human trainer at the present". (P9)

6 Recommendations for Improvement

Recommendations for improvement were mainly related to the usability of using a humanoid robot in similar situations. The older persons' recommendations for improvement were to include exercises for the entire body, not just the upper body, and to perform the exercises at a faster tempo. Some older persons also recommended including exercises that can be performed both sitting and standing, and one even recommended including floor push-ups. There were many concerns about the humanoid robot's inability to lift weights or heavier things. Some thought the size of the robot was appropriate because it was not intimidating, while others thought it was too small for its intended purpose. The use of a small humanoid robot for PTP was considered a challenge, e.g., some participants sitting further away had difficulties seeing the robot/exercises.

The older persons' recommendations for improvement were to improve the humanoid robot's speech and phrasing when giving instructions during the PTP session. In addition, the older persons recommended to allow the opportunities to ask the robot questions during an ongoing session. The majority of older persons perceived that humanoid robot-led PTP would better suit those older persons living in assisted living facilities and be more suitable for those persons in below-average physical condition or in need of additional physical or mental care, especially those for whom care professionals have insufficient time to provide such.

"When I visit friends at elderly homes, they just sit in their rooms and become inactive… it's important to participate in something fun, and then the robot and some kind of

exercise might be fun. At the same time, they get movement and socializing, which is important for those living in the homes". (P7)

7 Discussion

The aim of this qualitative pilot study was to investigate home-living older persons' experiences of a humanoid robot-led PTP and to explore their recommendations for further improvement before a full-scale study. The focus on suitable exercises for home-living older persons during the design process resulted in a PTP with an emphasis on upper body exercises. The study resulted in four overarching themes, which included: (1) acceptance of the robot, (2) value of exercises, (3) companionship, and (4) recommendations for improvement. The most common end-user experiences were that the exercises were both easy to follow and entertaining. However, all but one of the older persons maintained that the exercises were too easy and that more person-centered and challenging exercises suitable for home-living older persons in good physical condition should be included. We concluded that the humanoid robot-led PTP in its current form was not of added value with regard to the improvement of home-living older persons' physical condition but could positively influence their mental well-being and social interactions. In a recent study on aging with physical disabilities or long-term health conditions, Westwood et al. [22] found that physical decline reduce older persons' mobility, increase risk for falls and reduce the ability to perform basic tasks. Also in an earlier study, Colón-Emeric et al. [23] showed that older persons' physical decline constitute a reason why older persons cannot remain independent and continue to live at home. From this study's results, we found that older persons' average physical condition and exercise routines and needs vary and that a more person-centered humanoid robot-led PTP could increase end-user motivation.

Given that the physical condition of each home-living older person is unique, it would have been beneficial to involve the end users in all stages of the design process [24]. Therefore, we recommend that further research on humanoid robot-led PTP should include a focus on the inclusion of older persons during all stages of the design process to better ensure the development of programs whereby older persons can maintain, or even improve, their physical condition. However, even if using humanoid robots as robot exercise trainers in the care of older person show multi-domain functionality, majority of the older persons emphasized that robots could not replace human trainers in PTP, noting the importance of human empathy. Comparison studies could give a better understanding of the benefits and barriers associated with use of humanoid robots instead of human trainers, but also differences in using humanoid robots instead of non- humanoid robot technologies (e.g., a tele-robotics system or google home).

The humanoid robot-led PTP was only tested twice before being evaluated. That some older persons experienced the second once-weekly PTP session as being more positive than the first indicate that a humanoid robot-led PTP could become a positive habit over time. Also, the full involvement of home-living older persons during all stages of design, research and development [25] should have yielded a more motivating and engaging humanoid robot-led PTP.

The use of a participatory design approach [26] in the full-scale study could be considered effective because it could facilitate a broad assessment from various stakeholders of home-living older persons' average physical condition and exercise routines and needs. A participatory design approach enables the use of various methods and techniques during different stages of development, where even other external stakeholders, e.g., care professionals, can take part [23]. In addition, a user-centered design approach as described by Gulliksen et al. [27], in which the end-user is included from end to beginning, might also be suitable for development of the full-scale study.

Insight into home-living older persons' need for social companionship during a humanoid robot-led PTP was even revealed. This is in line with an earlier study [27], in which many home-living older persons were seen to experience loneliness and challenges in both retaining and maintaining social networks. Duner and Nordström [27] found that older persons remain autonomous for longer if surrounded by a strong social network. Consequently, one can question whether the at-home use of humanoid robots negatively affect older persons' social networks or also be a risk factor for even fewer social interactions. Although there are some positive effects associated with using robots in the care of older persons [28], more critical considerations and research are needed to find sustainable outcomes for their increased use. In accordance with Schutte [29], the feeling of community that the older persons in this study described after participating in the humanoid robot-led PTP can be seen as the experience of participation in a deeper context together with other human beings. Several Nordic researchers such as Jeppsson Grassman [30] and Svedberg von Essen and Jegermalm [31] also highlight that older persons continue to value being involved in societal development.

Finally, this study combines technology and a focus on developing care for older persons living at home. It addresses an innovative approach to improving the health and wellbeing of older persons. However, while involving additional stakeholders in the design of similar full-scale PTP study is a step towards addressing this issue, it may

not be the sole solution. Therefore, further research should identify potential limitations and refine the approach, such as the choice of methodology, accordingly. The full-scale survey should evaluate other qualitative methods to have a significant impact on the field of elderly care and robotics in care. For example, focus groups or participant observations could provide valuable insights into the complexity (both positive and negative) of human-robot interactions, as well as the contextual factors that influence the effectiveness of such interventions.

In accordance with the user-centred or participatory design considered appropriate and recommended for use in future full-scale studies, the end-to-end integration of older people in decision-making processes enables them to communicate their needs and wishes. The focus of future full-scale studies should either investigate the reason why physical health was not perceived to be positively affected by PTP. The second suggestion is that future full-scale studies should focus more on the positive outcomes that emerged in this study - such as older people's perception of improved mental and social health. In this pilot study this can be summarized as: *"*I felt [like I was] chosen to meet the robot". The older persons' positive experiences of the humanoid robot-led PTP might also have been influenced by their receiving attention through the act of participating.

8 Conclusion

The aim of this pilot study was to investigate home-living older persons' experiences of the humanoid robot-led PTP and their recommendations for further improvements. The home-living older persons experienced the program as easy to follow and that the program improve their mental well-being and social companionships. To positively influence older persons' physical condition, more person-centered exercises and a more suitable robot should be included. Further development of humanoid robot-led physical training programs is needed to ensure the usability of a similar programs in the context of older persons. In accordance with user-centered or participatory design approach deemed appropriate and recommended for use in further full-scale studies, the inclusion of older persons in decision-making processes enables them to communicate their needs and desires.

9 Limitations

The results should be interpreted with some caution. In future studies, the physical assessment of older persons by professionals should be undertaken during the design phase to ensure improved understanding of older persons' actual physical condition. The study's small sample size might also be considered a limitation. Taking the current shortage of humanoid robot functions and the results from this pilot study into consideration, the focus of the full-scale study should lie on the evaluation of humanoid robot-led PTP specifically designed for either home-living older persons in above-average or below-average physical condition. Given the positive outcomes related to mental well-being and social interactions seen in this pilot study, the full-scale study is recommended pursuant to a modification of the study design. Other methods, such as focus groups or participant observations, can offer valuable insights into the complexities of human-robot interactions, as well as the contextual factors influencing the effectiveness of such interventions. By capturing participants' perspectives in greater detail, the aim is to gain a comprehensive understanding of the mechanisms driving the impact (or lack thereof) of the PTP on the physical condition, mental well-being, and social interactions of older adults. In addition, it might be prudent to reconsider the viability of pursuing further research on this theme at this time. Instead, it may be valuable to redirect the efforts towards exploring alternative avenues of inquiry or reallocating resources towards interventions that show greater promise in addressing the needs of older populations.

Author Contributions All authors have made substantial contribution to the preparation of the manuscript and given final approval of the version to be published. NN, NN and NN planned the design of the study. NN and NN contributed to the data collection and data analysis. NN gave valuable comments to the manuscript.

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Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Code Availability Not applicable.

Declarations

Consent to Participate Written and verbal informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors report no conflict of interest.

References

1. Finnish institute for health and welfare policy (2018) https://thl.fi/en/web/ageing/ageing-policy
2. Finne-Soveri H, Mäkelä M, Noro A, Tepponen M (2014) Kotihoitoon on panostettava, jotta huonokuntoinenkin voi voida hyvin ja kuntoutua omassa kodissaan– case Eksote. https://www.julkari.fi/bitstream/handle/10024/120382/THL_TUTI_25_2014korjattu%2019%2012%202014.pdf?sequence=3%26isAllowed=y
3. Kataja MP (2016) Robotiikka tarvitsee lisää osaajia. Suomen sairaanhoitajaliitto, Hoitotyön vuosikirja: Teknologia sosiaali- ja terveydenhuollossa. Fioca oy, Helsinki
4. Ellenbecker M, Porell FW, Samia L, Byleckie JJ, Milburn M (2008) Predictors of home health nurse retention. J Nurs Scholarsh 40(2):151–160. https://doi.org/10.1111/j.1547-5069.2008.00220.x
5. Broadbent E, Tamagawa R, Patience A et al (2012) Attitudes towards health-care robots in a retirement village. Aust J Ageing 31(2):115–120. https://doi.org/10.1111/j.1741-6612.2011.00551.x
6. Winfield A (2012) Robotics: A very short introduction. OUP Oxford, pp 23
7. Graefe R, Bischoff V (2003) Past, present and future of intelligent robots. In: Computational Intelligence in Robotics and Automation, 78545492. https://doi.org/10.1109/CIRA.2003.1222283
8. Melkas H, Hennala L, Pekkarinen S et al (2020) Impacts of robot implementation on care personnel and clients in elderly-care institutions. Int J Med Inf 134. https://doi.org/10.1016/j.ijmedi2019.104041
9. Piezzo C, Suzuki K (2017) Feasibility study of a socially assistive Humanoid Robot for Guiding Elderly individuals during walking. Future Internet 9(3):30. https://doi.org/10.3390/fi9030030
10. Torta E, Werner FO, Johnson D et al (2014) Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly. J Intell Robot Syst 76:57–71. https://doi.org/10.1007/s10846-013-0019-0
11. Andtfolk M, Nyholm L, Eide H, Fagerström L (2021) Use of humanoid robots in the care of older persons: a scoping review. Assist Technol 34(5):518–526. https://doi.org/10.1080/10400435.2021.1880493
12. Ishiguro K, Majima Y, Sakata N (2016) Deployment of ARCS Model and utilization of Communication Robot in Patient Education. Int Joint Conf Biomed Eng Syst Technol 5:371–376. https://doi.org/10.5220/0005774603710376
13. Kouroupetroglou C, Casey D, Raciti M et al (2017) Interacting with dementia: the MARIO Approach. St Heal T 242:38–47. https://doi.org/10.3233/978-1-61499-798-6-38
14. Lehto P, Rantanen T (2017) Robotics in homecare - the development process through a case study. IATED 3444–3452. https://doi.org/10.21125/inted.2017.0864
15. Wu Y-H, Wrobel J, Cornuet M et al (2014) Acceptance of an assistive robot in older adults: a mixed-method study of human-robot interaction over a 1-month period in the living lab setting. Clinl Interv Aging 8(9):801–811. https://doi.org/10.2147/CIA.S56435
16. Bedaf S, Marti P, Amirabdollahian F et al (2018) A multi-perspective evaluation of a service robot for seniors: the voice of different stakeholders. Disabil Rehabil Assist Technol 13(6):592–599. https://doi.org/10.1080/17483107.2017.1358300
17. Alhmiedat T, Alotaibi M (2023) Employing Social Robots for managing diabetes among children: SARA. Wirel Pers Commun 130:449–468. https://doi.org/10.1007/s11277-023-10293-8
18. Alhmiedat T, Alotaibi M (2022) Design and evaluation of a Personal Robot playing a self-management for children with obesity. Electronics 11:4000. https://doi.org/10.3390/electronics11234000
19. World Health Organization (2018) Ageing and health. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed 10 February 2021
20. TENK, Finnish national board on research integrity (2019) The ethical principles of research with human participants and ethical review in the human sciences in Finland. Helsinki, Finland. https://www.tenk.fi/sites/tenk.fi/files/Ihmistieteiden_eettisen_ennakkoarvioinnin_ohje_2019.pdf. Accessed 10 February 2021)
21. Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual res Psychol 77–101. https://doi.org/10.1191/1478088706qp063oa
22. Westwood S, Carey N (2018) Ageing with physical disabilities and/or long-term health conditions. In Ageing, Diversity and Equality: Social Justice Perspectives 54(2), pp 225–244
23. Colón-Emeric C, Whitson HE, Pavon J et al (2013) Functional decline in older adults. AM Fam Physician 88(6):388–394
24. Sanders EB-N, Stappers PJ (2008) Co-creation and the new landscapes of design. CoDesign 4:5–18. https://doi.org/10.1080/15710880701875068
25. Gulliksen J, Göransson B, Boivie I et al (1999) Key principles for user-centred systems design. Behav Inf Technol 22(6):97–409. https://doi.org/10.1080/014492903100016243 29
26. Muller M, Kuhn S (1993) Participatory Design. Commun ACM 36(6):24–28. https://doi.org/10.1145/153571.255960
27. Duner A, Nordstrom M (2007) The roles and functions of the informal support networks of older people who receive formal support: a Swedish qualitative study. Ageing Soc 27(1):67–85. https://doi.org/10.1017/S0144686X06005344
28. Shishehgar M, Kerr D, Blake J (2019) The effectiveness of various robotic technologies in assisting older adults. Health Inf J 25(3):829–918. https://doi.org/10.1177/1460458217729729
29. Schutte DW (2016) Community development and community participation: a conceptual revisit. https://doi.org/10.13140/RG.2.2.22723.81443
30. Jeppsson Grassman E (2005) På jakt efter den frivilliga sektorns roll inom nordisk äldreomsorg. Forskning, gestaltningar och perspektiv. In: Szebehely M (Red.) (ed) Äldreomsorgsforskning i Norden. En kunskapsöversikt, Köpenhamn, pp 281–320
31. von Svedberg J, Jegermalm M (2010) Svenskarnas Ideella Engagemang är större än någonsin. Insatser i och utanför föreningslivet. Ersta Sköndal högskola arbetsrapportserie, Stockholm