Repeat After Me: Dynamic Workouts for The Wellbeing of Elderly Individuals with Dementia

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In the past two decades, social robots have been utilized in the healthcare of elderly individuals with dementia to assist in exercising and companionship. In this research, we investigated whether elderly individuals with dementia were more engaged when receiving varying mobility sessions from a social robot than non-varying mobility sessions. Groups of elderly individuals with dementia (N=18) of differing dementia levels participated in three exercise sessions either with varying sessions (n=9) or with non-varying sessions (n=9). Our results show a small improvement in engagement in varied sessions compared to non-varied sessions, however, the difference was not significant. Additionally, the study gives insights into the application of this technology and the challenges involved in conducting this type of experiment.

Keywords: dementia, elderly care, social robots, engagement, mobility

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1 Introduction

As society faces an ever-increasing aging population (Kanasi et al., 2016; Luchsinger, 2023), different systems are under greater strain (Lee & Mason, 2017). These strains are particularly evident in elderly care, where there is a shortage of caregivers (Resnick et al., 2022) while care must be provided to an increasing influx of elderly patients. That is, by 2023, there were 55 million people worldwide with dementia, most of them elderly people, with 10 million new cases added every year (World Health Organization, 2023).

This development has inspired research into the application of technological innovations to improve the quality of life for this ever-increasing aging population (Fares et al., 2021; Penno & Gauld, 2017; Stone & Harahan, 2010). Further research is needed because in the US, for example, only half of the geriatricians needed for elderly care are available because of a financial disadvantage (e.g., there is a decrease in income when becoming a geriatrician due to the fee-for-service system) (Rowe et al., 2016). This exacerbates loneliness among the elderly population (Gardiner et al., 2020; James Alexander Crewdson, 2016), which can affect physical and mental health (James Alexander Crewdson, 2016). Especially when it comes to elderly individuals with dementia, who experience even more social loneliness than those without dementia (Holmén et al., 2000). Due to these concerns, different methods and technologies are being explored for the healthcare system.

One example of the exploration of technology is the use of social robots (SRs), which proofs to be applicable in healthcare (Aymerich-Franch & Ferrer, 2021). That is, SRs can become a tool for a caregiver, to ease or support care for the elderly (Kachouie et al., 2014). Previous research has shown the potential of SRs in healthcare. For example, the companion robot Paro provided a positive experience when it was used as a comfort buddy for the elderly (Chen et al., 2022). Indeed, Paro is a robotic seal used in elderly care for companionship, emotional support, and as a distraction for patients exhibiting challenging behavior (Wada et al., 2003). Moreover, Paro has also been shown to have positive effects on elderly individuals with dementia in particular (Kang et al., 2020; Kelly et al., 2021). Another example of using the application of SRs to assist elderly individuals with dementia is the use of the Tessa robot from tinyBots, which can help elderly individuals with dementia establish a daily structure using reminders (Smit et al., 2021).

Offering multicomponent interventions, which include physical activity, to older people with dementia can alleviate the negative effects of dementia (Blankevoort et al., 2010). Moreover, exercise can be effective in maintaining and improving the health of elderly people (Dawe & Moore-Orr, 1995; McMurdo & Rennie, 1993). A SR could be useful in this regard, as it can be used as an on-demand exercise program (Lotfi et al., 2018). With this in mind, the SR NAO can be of particular interest due to its humanoid form and the wide range of motion possible with this robot (Robaczewski et al., 2021). Furthermore, to ensure that participants remain motivated and focused during the exercises, the session should remain engaging for them. Since there are different stages of dementia (Reisberg et al., 1982), a later stage of dementia may affect engagement due to the novelty effect (Suchy et al., 2011). In this context, the novelty effect can occur again because elderly individuals with dementia cannot remember a previous session and therefore experience the same exercise as new. However, this novelty effect may not apply to the elderly with early-onset dementia, who might remember the previous, and therefore, the repetition of exercises may negatively impact engagement. To explore the effect of repeating exercises on the engagement of elderly individuals with dementia, we beg to answer the following main research question in this paper: "*How does introducing a new exercise routine through three sessions with an NAO robot affect the engagement of elderly individuals with dementia?*"

2 Background and Related Work

With a limited number of caregivers, there is a need to address the shortage so that the elderly get the care they need (Resnick et al., 2022). Besides, elderly individuals with dementia need even more support with daily activities, i.e., elderly individuals with dementia often need help with traveling or become incontinent, depending on the stage of dementia (Reisberg et al., 1982). Moreover, it is important for the quality of life that elderly individuals with dementia in long-term care facilities have the opportunity to participate in meaningful physical activities (Sampaio et al., 2021; Telenius et al., 2022). This is because physical activities are associated with a reduced risk of dementia (Kirk-Sanchez & McGough, 2013) and have been shown to have a significant positive treatment effect on elderly individuals with dementia (Heyn et al., 2004). It introduces benefits such as reducing depression, improving cognitive skills, and consequently improving the quality of life (Zhou et al., 2022). Regarding physical activity, a greater positive effect on cognition in people with dementia was found with physical activity of less than 30 minutes (Jia et al., 2019). Therefore, arranging a physical activity for the elderly can take up to 30 minutes, but as caregivers have little time, a solution is needed.

One solution could be to use SRs that help support activities for elderly individuals with dementia. For example, one study demonstrated the suitability of telepresence robots for remote research because they evoke more engagement in people with dementia compared to Skype or phone calls (Hung et al., 2023). Another example is that elderly individuals with dementia have benefited from a SR pet which was often used on a daily basis (Harris-Gersten et al., 2023). Moreover, caregivers found that SRs can improve physical activity by, e.g., motivating and guiding elderly individuals to exercise (Zuschnegg et al., 2022). For example, research included dance sessions led by the SRs Pepper and NAO, in which the robots invited elderly individuals (without dementia) to dance (Li et al., 2022). These dance sessions were positively received by both the elderly and the caregivers (Li et al., 2022). Such an approach could help maintain physical functionality without increasing the burden on caregivers. Moreover, it also provides opportunities for conversations between people with dementia by coming together in a common room to engage with a SR (Blindheim et al., 2023). For example, research showed that using a SR led to conversation and joking in the common room of a long-term care facility (Blindheim et al., 2023). Besides physical activities, SRs can help people with dementia by communicating with them, which also improves their quality of life through engagement (Mordoch et al., 2013). In addition, SRs can provide assistance by communicating in group sessions, allowing caregivers to provide individual support when needed (Raß et al., 2023). Lastly, it was found that caregivers felt that a SR could help them avoid danger, e.g., by preventing injury through assistance in walking (Zuschnegg et al., 2022).

Research, on the other hand, shows that even though SRs can be used to help in healthcare, there are still some areas for improvement. For example, research with a robot used to comfort children before a blood draw showed that caregivers do not have all the time or experience to use such a SR (Smakman et al., 2021). In addition, functionalities of a SR are also missed due to, e.g., not being aware of certain keyboard shortcuts when using a SR (Blindheim et al., 2023). Moreover, when AI is built into a SR that monitors elderly individuals with dementia, recognizing speech patterns can be an issue because the speech of a person with dementia is sometimes unclear. This can lead to failure to summon help, for example, because the robot does not pick up on the user's behavior properly (Felzmann, 2020). This is due to the problem of SRs being used to help vulnerable individuals and not being able to understand their vulnerability themselves (Ragno et al., 2023). Furthermore, Misselhorn et al. (2013) argue that a SR should not replace human-*human* interaction, as it is important to be empathetic towards the person with dementia. Moreover, caregivers also expressed concerns about the usability of SRs for people with dementia, as computer interfaces would be inaccessible to these people (Pino et al., 2015). Finally, caregivers expressed concern about SRs looking too much like humans, as they might confuse individuals with dementia (Pino et al., 2015). On the other hand, an elderly individual with dementia in research suggested that the SR used looked too mechanical (Moyle et al., 2016).

In conclusion, research has shown that SRs can help elderly individuals with dementia in many ways, through physical activity and sociability, both one-on-one and in group settings, despite there being areas for improvement. However, to the knowledge of the authors, no research has yet been conducted on the engagement of older people with dementia with SRs and whether the difference in type of exercises affects engagement.

3 Research Method

The purpose of this research was to determine the extent to which varying exercise sessions improve the engagement of elderly individuals with dementia compared to non-varying exercise sessions. Therefore, the same experiment was conducted twice with two separate groups. In addition, a short interview with caregivers was conducted.

In the first session, both groups included the same exercise session. In the second session, the non-varied group included the same exercise session, while the varied group had a different one. In the third session, the non-varied group again included the same exercise session, while the varied group, once again, received a different exercise session along with additional human-voiced instructions through the NAO robot. The robot executed various exercises based on gym workouts and dances, as these were observed to be enjoyable to other elderly individuals (Li et al., 2022). The exercises by the robot were developed after interviews with several caregivers about their strategies for motivating the elderly to engage in physical activity. These exercise sessions were created using the 'Robots in de klas' and 'Choreographe' platforms. In addition, the robot movements were designed to allow the elderly to perform an entire exercise session in a seated position for safety. To complement the exercise sessions, NAO had sporty wrist and headbands, as shown in Figure 1.

Figure 1: NAO Robot and Observer
Source: Own

To consistently measure and evaluate participant engagement, an adapted version of the ZIKO evaluation instrument (Self-evaluation Instrument for Care Settings) was used (Laevers, 2005). The adapted version of this evaluation instrument for robot interactions has more often been used with children in human-robot interactions (de Haas et al., 2022). Although this form is originally designed for children of 5 years old, it is also applicable to the elderly with dementia because the decline in cognitive abilities over time can reach a point where it intersects with the cognitive development of children (Rubial-Álvarez et al., 2012). Additionally, the engagement instrument emphasizes the interaction that the elderly with dementia had with both the tasks and the robot. Given that the exercises provided by the robot were relatively simple, the engagement instrument had criteria for the specific moments of interest related to the robot's behavior. Therefore, we argue that ZIKO is an appropriate measurement instrument in this study. The form includes an evaluation scale ranging from 1 (extremely low) to 5 (extremely high), with specific criteria for each level of engagement. Using this form, the overall engagement of the elderly could be consistently and accurately assessed. To ensure the validity of the instrument, each elderly individual was coded twice by two researchers and the mean of the scores was used.

The experiment took place in two different retirement homes in the Netherlands that were visited three separate times with a week between sessions. The participants were 65 years and older and consisted of both men and women. A purposive sample was used to ensure that only elderly people with different stages of dementia participated, detemined by their caregivers, excluding those with early-onset dementia. Only participants who were able to give informed consent were approached and asked if they wanted to participate in the experiment. Participants signed a consent form and if at any time they decided not to participate, they could opt out. The experiment took place in two retirement homes, where caregivers selected the participants and divided the participants randomly into four groups of four/five people. This resulted in two non-varied groups (NV) of a total of nine participants and two varied groups (V) of a total of nine participants. During each visit, group NV performed the same exercise session, while group V was presented with a different session each time.

In each 10-minute exercise session, participants were brought into a room and placed on stools in a semicircle around a table on which the NAO robot stood. By placing NAO on a table, its instructions were easier for participants to see. The robot gave verbal instructions on what to do and demonstrated the instructions through movements. In each session, the robot introduced itself at the beginning and informed participants about what would happen during the session. Then the 10-minute practice session begins with exercises such as twisting the wrists, opening and closing the fingers, and forward punches. Each of these exercise sessions consists of a program that the robot will execute. After each session, the robot expressed thanks for the participation and wished the participants goodbye. During the exercise sessions, the engagement of each participant with NAO was graded by two researchers at two 5-minute intervals as described above. After the three sessions, the caretakers were interviewed to reflect on the robot interaction.

4 Data Analysis and Results

Before the data was analyzed, engagement scores were calculated. To ensure a non-biased engagement score, the average score was used during the data analysis of two researchers who individually scored the participants. Moreover, a mean score per session was calculated for each participant, leading to three scores for each participant in total. Not every participant was able to attend every session (session 1: n = 18, session 2: n = 15, session 3: n =15). The average engagement scores of each group of participants per session are shown in Figure 2. Because of the small sample size, we were not able to perform any statistical analyses.

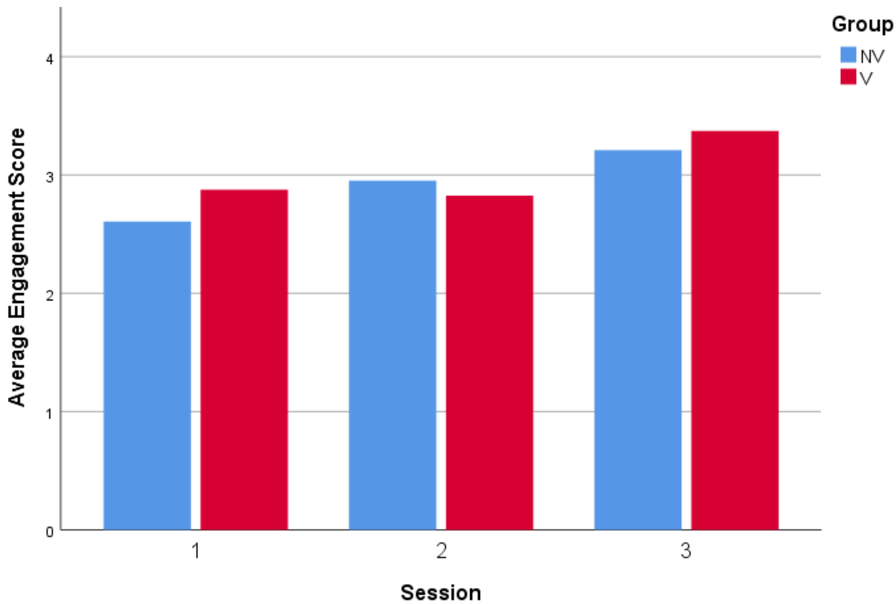

Figure 2: Average engagement score of all participants per session
Source: Own

Figure 2 shows that the scores for the elderly were approximately the same across each session and there are only small differences. That is, there is a slight increase in engagement between the first and third sessions in both groups (for group NV, session one: M = 2.61 and session three: M = 3.21, for group V, session one: M = 2.87 and session three: M = 3.37). Despite the scores in both groups increasing slightly each session, there is no statistically significant difference, due to the overall scores for the two conditions being roughly similar.

5 Discussion and Future Research

The goal of this research was to evaluate whether introducing varied exercise sessions increases the engagement of elderly individuals with dementia compared to non-varied sessions. The data showed that there is no difference in engagement between the varied and non-varied groups. The lack of difference could be explained by several factors that occurred during the experiment. First, the different stages of dementia of the participants may have influenced the data, as this would explain the wide range of engagement scores. However, the decline is not present at all stages. For this reason, it is therefore important to conduct future research validating the results of this study. Second, it is possible that the ZIKO form, developed for children, might not have been entirely accurate because there could have been a difference in children's cognitive skills and elderly with dementia in an earlier stage of dementia. Third, an interview with caregivers present during the experiment revealed that participants could benefit more from a higher grade of individualization of the robot's exercise program. For example, addressing a participant by name or responding differently to elderly individuals with dementia, depending on their engagement in the exercises. Therefore, future research is needed on personalizing exercises by, e.g., increasing length or difficulty, and personally addressing the elderly. In addition, future research is needed on how exercises can be adapted to different stages of dementia, combined with using a SR. Fourth, it was also mentioned by the caregivers that participants found it more difficult to follow smaller motor skill movements made by the robot such as opening and closing hands, compared to larger motor skill movements such as stretching the arms. Fifth, the different timing of the sessions may also have played a role. It was not possible to schedule all sessions at the same time of day. Some sessions took place in the morning and others in the afternoon. The different times of the sessions may have also affected engagement scores, as some participants were more active in the morning and others in the afternoon. Sixth,, the experiment included 18 participants. This makes it impossible to generalize our conclusions to a larger population and to perform analyses to confirm our hypotheses statistically. Future research is needed in which this experiment is repeated with a larger sample size of elderly individuals with dementia, thereby increasing the overall statistical relevance and generalizability of the findings. However, elderly with dementia are a particularly difficult group to recruit, since not all of them have the power of attorney. As a result, recruitment must be done through their immediate relatives, which lengthens and complicates the recruitment period. Besides that, the sessions took place in December, which also reduced participant recruitment due to national holidays. Moreover, it was also difficult to recruite participants because of the study's timeframe. During the experiment, the robot also drew the attention of other residents and caregivers at the care homes. Although many of them found the robot interesting, they did not want to participate in the study and commit to it for three sessions. This resulted in these extra participants in the background not being graded and not being included in the research data. Future studies should take this into account.

Finally, the retirement homes could also already have offered exercise activities, which were not checked for or taken into account. The introduction of the unfamiliar robot sessions, which were focused on physical exercise, could have been made less interesting by this.

6 Conclusion

With the growing aging population, the number of elderly with dementia is constantly increasing. However, the time caregivers have to provide individual care and attention is limited, requiring new solutions for the care of elderly individuals with dementia. SRs may be a key solution, helping with the daily activities of elderly individuals with dementia and thereby improving their quality of life. This paper investigated whether the engagement of the elderly with dementia would change by conducting an experiment that involved exercise sessions with the SR NAO. To do so, we tried to answer the following research question: "*How does introducing a new exercise routine through three sessions with an NAO robot affect the engagement of elderly individuals with dementia?*" The results revealed that there indeed was a small improvement in engagement in varied sessions compared to non-varied sessions, however, the difference was small. Despite that, the elderly with dementia often showed an interest in the robot, even if they did not perform the movements instructed by the robot. From a theoretical point of view, this research contributed to the body of knowledge of social robotics, providing research on the engagement of elderly with dementia in exercise sessions given by a robot. The difference between exercise variation and no exercise variation shows that future research is needed to validate this further. From a practical point of view, this research contributes to the practical application of SRs in healthcare, specifically in helping the elderly with dementia and relieving and assisting caregivers. Care homes can use technology, such as SR, to encourage movement in elderly individuals with dementia, which seems to have a small effect, though this has not yet been significantly demonstrated.

References

Aymerich-Franch, L., & Ferrer, I. (2021). Socially assistive robots' deployment in healthcare settings: a global perspective. CoRR, abs/2110.07404. https://arxiv.org/abs/2110.07404

Blankevoort, C. G., van Heuvelen, M. J. G., Boersma, F., Luning, H., de Jong, J., & Scherder, E. J. A. (2010). Review of Effects of Physical Activity on Strength, Balance, Mobility and ADL Performance in Elderly Subjects with Dementia. Dementia and Geriatric Cognitive Disorders, 30(5), 392–402. https://doi.org/10.1159/000321357

Blindheim, K., Solberg, M., Hameed, I. A., & Alnes, R. E. (2023). Promoting activity in long-term care facilities with the social robot Pepper: a pilot study. Informatics for Health and Social Care, 48(2), 181–195. https://doi.org/10.1080/17538157.2022.2086465

Chau, S. A., Herrmann, N., Eizenman, M., Chung, J., & Lanctôt, K. L. (2015). Exploring Visual Selective Attention towards Novel Stimuli in Alzheimer's Disease Patients. Dementia and Geriatric Cognitive Disorders Extra, 5(3), 492–502. https://doi.org/10.1159/000442383

Chen, S.-C., Davis, B. H., Kuo, C.-Y., Maclagan, M., Chien, C.-O., & Lin, M.-F. (2022). Can the Paro be my Buddy? Meaningful experiences from the perspectives of older adults. Geriatric Nursing, 43, 130–137. https://doi.org/10.1016/j.gerinurse.2021.11.011

Dawe, D., & Moore-Orr, R. (1995). Low-intensity, range-of-motion exercise: invaluable nursing care for elderly patients. Journal of Advanced Nursing, 21(4), 675–681. https://doi.org/10.1046/j.1365-2648.1995.21040675.x

de Haas, M., Vogt, P., van den Berghe, R., Leseman, P., Oudgenoeg-Paz, O., Willemsen, B., de Wit, J., & Krahmer, E. (2022). Engagement in longitudinal child-robot language learning interactions: Disentangling robot and task engagement. International Journal of Child-Computer Interaction, 33, 100501. https://doi.org/10.1016/j.ijcci.2022.100501

Fares, N., Sherratt, R. S., & Elhajj, I. H. (2021). Directing and Orienting ICT Healthcare Solutions to Address the Needs of the Aging Population. Healthcare, 9(2), 147. https://doi.org/10.3390/healthcare9020147

Felzmann, H. (2020). Can a Robot Provide the Answer? Ethical Considerations in Using Social Robots for Assessment and Monitoring in Healthcare. In Developing and Utilizing Digital Technology in Healthcare for Assessment and Monitoring (pp. 29–44). Springer International Publishing. https://doi.org/10.1007/978-3-030-60697-8_3

Gardiner, C., Laud, P., Heaton, T., & Gott, M. (2020). What is the prevalence of loneliness amongst older people living in residential and nursing care homes? A systematic review and meta-analysis. Age and Ageing, 49(5), 748–757. https://doi.org/10.1093/ageing/afaa049

Harris-Gersten, M. L., Davagnino, J. M., Alcorn, E. R., & Hastings, S. N. (2023). Usability and Acceptability of Social Robot Pets Among Community-Dwelling Veterans Living With Dementia and Their Caregivers. American Journal of Alzheimer's Disease & Other Dementias®, 38. https://doi.org/10.1177/15333175231200973

Heyn, P., Abreu, B. C., & Ottenbacher, K. J. (2004). The effects of exercise training on elderly persons with cognitive impairment and dementia: A meta-analysis11No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) is/are associated. Archives of Physical Medicine and Rehabilitation, 85(10), 1694–1704. https://doi.org/10.1016/j.apmr.2004.03.019

Holmén, K., Ericsson, K., & Winblad, B. (2000). Social and emotional loneliness among non-demented and demented elderly people. Archives of Gerontology and Geriatrics, 31(3), 177–192. https://doi.org/10.1016/S0167-4943(00)00070-4

Hung, L., Lake, C., Hussein, A., Wong, J., & Mann, J. (2023). Using telepresence robots as a tool to engage patient and family partners in dementia research during COVID-19 pandemic: a qualitative participatory study. Research Involvement and Engagement, 9(1), 12. https://doi.org/10.1186/s40900-023-00421-w

Ince Yenilmez, M. (2015). Economic and Social Consequences of Population Aging the Dilemmas and Opportunities in the Twenty-First Century. Applied Research in Quality of Life, 10(4), 735–752. https://doi.org/10.1007/s11482-014-9334-2

James Alexander Crewdson. (2016). The Effect of Loneliness in the Elderly Population: A Review. Healthy Aging & Clinical Care in the Elderly, 8, 1–8. https://doi.org/10.4137/HACCE.S35890

Jia, R., Liang, J., Xu, Y., & Wang, Y. (2019). Effects of physical activity and exercise on the cognitive function of patients with Alzheimer disease: a meta-analysis. BMC Geriatrics, 19(1), 181. https://doi.org/10.1186/s12877-019-1175-2

Kachouie, R., Sedighadeli, S., Khosla, R., & Chu, M.-T. (2014). Socially Assistive Robots in Elderly Care: A Mixed-Method Systematic Literature Review. International Journal of Human-Computer Interaction, 30(5), 369–393. https://doi.org/10.1080/10447318.2013.873278

Kanasi, E., Ayilavarapu, S., & Jones, J. (2016). The aging population: demographics and the biology of aging. Periodontology 2000, 72(1), 13–18. https://doi.org/10.1111/prd.12126

Kang, H. S., Makimoto, K., Konno, R., & Koh, I. S. (2020). Review of outcome measures in PARO robot intervention studies for dementia care. Geriatric Nursing, 41(3), 207–214. https://doi.org/10.1016/j.gerinurse.2019.09.003

Kelly, P. A., Cox, L. A., Petersen, S. F., Gilder, R. E., Blann, A., Autrey, A. E., & MacDonell, K. (2021). The effect of PARO robotic seals for hospitalized patients with dementia: A feasibility study. Geriatric Nursing, 42(1), 37–45. https://doi.org/10.1016/j.gerinurse.2020.11.003

Kirk-Sanchez, N., & McGough, E. (2013). Physical exercise and cognitive performance in the elderly: current perspectives. Clinical Interventions in Aging, 51. https://doi.org/10.2147/CIA.S39506

Laevers, F. (2005). Well-being and Involvement in care settings. A process-oriented Self-evaluation Instrument (SIC's). https://api.semanticscholar.org/CorpusID:203489187

Lee, R., & Mason, A. (2017). Cost of Aging. Finance & Development.

Li, Y., Liang, N., Effati, M., & Nejat, G. (2022). Dances with Social Robots: A Pilot Study at Long-Term Care. Robotics, 11(5), 96. https://doi.org/10.3390/robotics11050096

Lotfi, A., Langensiepen, C., & Yahaya, S. (2018). Socially Assistive Robotics: Robot Exercise Trainer for Older Adults. Technologies, 6(1), 32. https://doi.org/10.3390/technologies6010032

Luchsinger, G. (2023). World social report 2023: Leaving no one behind in an ageing world. United Nations: Department of Economic and Social Affairs.

McMurdo, M. E. T., & Rennie, L. (1993). A Controlled Trial of Exercise by Residents of Old People's Homes. Age and Ageing, 22(1), 11–15. https://doi.org/10.1093/ageing/22.1.11

Misselhorn, C., Pompe, U., & Stapleton, M. (2013). Ethical Considerations Regarding the Use of Social Robots in the Fourth Age. GeroPsych, 26(2), 121–133. https://doi.org/10.1024/1662-9647/a000088

Mordoch, E., Osterreicher, A., Guse, L., Roger, K., & Thompson, G. (2013). Use of social commitment robots in the care of elderly people with dementia: A literature review. Maturitas, 74(1), 14–20. https://doi.org/10.1016/j.maturitas.2012.10.015

Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V. (2016). What Effect Does an Animal Robot Called CuDDler Have on the Engagement and Emotional Response of Older People with Dementia? A Pilot Feasibility Study. International Journal of Social Robotics, 8(1), 145–156. https://doi.org/10.1007/s12369-015-0326-7

Natarajan, M., & Gombolay, M. (2020). Effects of Anthropomorphism and Accountability on Trust in Human Robot Interaction. Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction, 33–42. https://doi.org/10.1145/3319502.3374839

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Current Opinion in Psychiatry, 18(2), 189–193. https://doi.org/10.1097/00001504-200503000-00013

Penno, E., & Gauld, R. (2017). Change, Connectivity, and Challenge: Exploring the Role of Health Technology in Shaping Health Care for Aging Populations in Asia Pacific. Health Systems & Reform, 3(3), 224–235. https://doi.org/10.1080/23288604.2017.1340927

Pino, M., Boulay, M., Jouen, F., & Rigaud, A.-S. (2015). "Are we ready for robots that care for us?" Attitudes and opinions of older adults toward socially assistive robots. Frontiers in Aging Neuroscience, 7. https://doi.org/10.3389/fnagi.2015.00141

Ragno, L., Borboni, A., Vannetti, F., Amici, C., & Cusano, N. (2023). Application of Social Robots in Healthcare: Review on Characteristics, Requirements, Technical Solutions. Sensors, 23(15), 6820. https://doi.org/10.3390/s23156820

Raß, E., Unbehaun, D., Wulf, V., Lüssem, J., Eilers, H., Lenz, G., Tandler, J., Afzali, S. N., & Eroglu, B. (2023). Investigating the Potential and Impacts of Social Robots to Engage People with Advanced Dementia and their Caregivers: Early Insights from an Exploratory Ethnographic Study within a Protected Care Environment. Proceedings of the 16th International Conference on PErvasive Technologies Related to Assistive Environments, 272–278. https://doi.org/10.1145/3594806.3594826

Reisberg, B., Ferris, S. H., de Leon, M. J., & Crook, T. (1982). The Global Deterioration Scale for assessment of primary degenerative dementia. American Journal of Psychiatry, 139(9), 1136–1139. https://doi.org/10.1176/ajp.139.9.1136

Resnick, B., Young, H. M., Fick, D. M., & Kagan, S. H. (2022). Making care for older people the choice of nurses today, tomorrow, and forever. Geriatric Nursing, 46, A1–A2. https://doi.org/10.1016/j.gerinurse.2022.04.014

Robaczewski, A., Bouchard, J., Bouchard, K., & Gaboury, S. (2021). Socially Assistive Robots: The Specific Case of the NAO. International Journal of Social Robotics, 13(4), 795–831. https://doi.org/10.1007/s12369-020-00664-7

Rowe, J. W., Fulmer, T., & Fried, L. (2016). Preparing for Better Health and Health Care for an Aging Population. JAMA, 316(16), 1643. https://doi.org/10.1001/jama.2016.12335

Rubial-Álvarez, S., de Sola, S., Machado, M.-C., Sintas, E., Böhm, P., Sánchez-Benavides, G., Langohr, K., Muñiz, R., & Peña-Casanova, J. (2012). The Comparison of Cognitive and Functional Performance in Children and Alzheimer's Disease Supports the Retrogenesis Model. Journal of Alzheimer's Disease, 33(1), 191–203. https://doi.org/10.3233/JAD-2012-121123

Sampaio, A., Marques-Aleixo, I., Seabra, A., Mota, J., & Carvalho, J. (2021). Physical exercise for individuals with dementia: potential benefits perceived by formal caregivers. BMC Geriatrics, 21(1), 6. https://doi.org/10.1186/s12877-020-01938-5

Scoglio, A. A., Reilly, E. D., Gorman, J. A., & Drebing, C. E. (2019). Use of Social Robots in Mental Health and Well-Being Research: Systematic Review. Journal of Medical Internet Research, 21(7), e13322. https://doi.org/10.2196/13322

Smakman, M. H. J., Smit, K., Buser, L., Monshouwer, T., van Putten, N., Trip, T., Schoof, C., Preciado, D. F., Konijn, E. A., van der Roest, E. M., & Tiel Groenestege, W. M. (2021). Mitigating Children's Pain and Anxiety during Blood Draw Using Social Robots. Electronics, 10(10), 1211. https://doi.org/10.3390/electronics10101211

Smit, K., Smakman, M., Bakker, S., Blokhuis, J., Evertzen, G., & Polman, L. (2021). Hello, is Someone There? A Case Study for Using a Social Robot in Dementia Care. 34th Bled EConference Digital Support from Crisis to Progressive Change: Conference Proceedings, 529–546. https://doi.org/10.18690/978-961-286-485-9.38

Stone, R., & Harahan, M. F. (2010). Improving The Long-Term Care Workforce Serving Older Adults. Health Affairs, 29(1), 109–115. https://doi.org/10.1377/hlthaff.2009.0554

Suchy, Y., Kraybill, M. L., & Franchow, E. (2011). Practice Effect and Beyond: Reaction to Novelty as an Independent Predictor of Cognitive Decline Among Older Adults. Journal of the International Neuropsychological Society, 17(01), 101–111. https://doi.org/10.1017/S135561771000130X

Suttanon, P., Hill, K. D., Said, C. M., LoGiudice, D., Lautenschlager, N. T., & Dodd, K. J. (2012). Balance and Mobility Dysfunction and Falls Risk in Older People with Mild to Moderate Alzheimer Disease. American Journal of Physical Medicine & Rehabilitation, 91(1), 12–23. https://doi.org/10.1097/PHM.0b013e31823caeea

Telenius, E. W., Tangen, G. G., Eriksen, S., & Rokstad, A. M. M. (2022). Fun and a meaningful routine: the experience of physical activity in people with dementia. BMC Geriatrics, 22(1), 500. https://doi.org/10.1186/s12877-022-03149-6

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003). Psychological and social effects of robot assisted activity to elderly people who stay at a health service facility for the aged. 2003 IEEE International Conference on Robotics and Automation, 3996–4001. https://doi.org/10.1109/ROBOT.2003.1242211

World Health Organization. (2023, March 15). Dementia. https://www.who.int/news-room/fact-sheets/detail/dementia

Zhou, S., Chen, S., Liu, X., Zhang, Y., Zhao, M., & Li, W. (2022). Physical Activity Improves Cognition and Activities of Daily Living in Adults with Alzheimer's Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. International Journal of Environmental Research and Public Health, 19(3), 1216. https://doi.org/10.3390/ijerph19031216

Zuschnegg, J., Paletta, L., Fellner, M., Steiner, J., Pansy-Resch, S., Jos, A., Koini, M., Prodromou, D., Halfens, R. J. G., Lohrmann, C., & Schüssler, S. (2022). Humanoid socially assistive robots in dementia care: a qualitative study about expectations of caregivers and dementia trainers. Aging & Mental Health, 26(6), 1270–1280. https://doi.org/10.1080/13607863.2021.1913476