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PROFESSIONAL APPLICATION

The Application of Artificial Intelligence in Digital Physical Activity and Falls Prevention Interventions for Older Adults

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This article discusses the practical applications of artificial intelligence in digital physical activity and falls prevention interventions for older adults. It notes the range of technologies that can be used to collect digital datasets on older adult health and how machine learning algorithms can be applied to these to improve our understanding of physical activity and falls. In particular, these advanced computational techniques could help personalize exercises, feedback, and notifications to older people, improve adherence to and reduce attrition from digital health interventions, and enhance monitoring by providing predictive analytics on the physiological and environmental conditions that contribute to physical activity and falls in aging populations.

***Keywords**:* artificial intelligence

The World Health Organization (2017) estimates there will be a significant rise in the number of people aged 60 and older, increasing from 900 million to 2 billion worldwide between 2015 and 2050. Physical, psychological, and social health changes associated with aging increase the risks of falls and falls-related injuries, which are the principal cause of accidental death in older people. An estimated 30% of older adults experience one or more falls annually (National Institute for Health and Care Excellence, 2018), a global problem leading to high health and social care costs due to ambulance call outs, costly fractures and hospital admissions, premature admission to care homes, reduced functioning, and loss of confidence that can lead to social isolation and increased dependency (National Institute for Health and Care Excellence, 2013). There is strong scientific evidence that specific strength and balance exercises of sufficient dose and challenge can reduce approximately one third of falls (Sherrington et al., 2019). Digital physical activity interventions are being designed to improve access, uptake, and adherence to exercise programs among older adults to help reduce falls rates and minimize their negative consequences (Stanmore et al., 2019).

Digital physical activity interventions can take many forms. These include online platforms where a person can watch exercise videos, exergames with wearable devices that monitor and encourage specific physical activities, and newer augmented and virtual reality applications where users are immersed in semi- or fully digital environments to enhance the exercise experience (Choi et al., 2021; O'Connor, 2019). With all these approaches, electronic data sets can be gathered from users, and these data analyzed to understand their levels of engagement with the digital intervention (e.g., frequency, duration, timing, and location of use), its impact on their quality of life, and their general levels of mobility and health. Given the volume of complex data that can be collected from different types of digital exercise programs, more sophisticated Artificial Intelligence (AI) analytical approaches are now being applied to try and improve the prediction of falls and related outcomes to support the physical, mental, and social health of older adults (O'Connor et al., 2022). More specifically, we consider here how two facets of AI, Natural Language Processing, and machine learning are starting to be integrated within digital physical activity interventions.

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Personalized Exercises, Feedback, and Notifications

Personalizing the experience of using a digital physical activity intervention could improve how often and for how long older adults engage with it. Unsupervised machine learning techniques (i.e., clustering analysis) may provide a more in-depth understanding of specific groups of older adults (e.g., age, gender, ethnicity, level of education/literacy) and their preferences for different forms of exercise, an approach used in other domains in health care (Rahman et al., 2017). For example, a group of older people with a high number of repetitions per exercise and a lower duration of application use per day could correspond to those who are fitter and healthier. By identifying these clusters, groups with specific needs could be offered more tailored suggestions for physical activity that suits their abilities. Over time, personalized feedback on completed exercise activities, general mobility, overall health status, and other trends could be generated and provided to each older user as a form of positive reinforcement and to encourage further engagement with a digital physical activity intervention. Virtual health assistants in the form of AI chatbots are also being developed through a combination of machine learning and Natural Language Processing techniques to support physical activity in older persons (Zhang et al., 2020). In these systems, users engage with an AI by typing free text or speaking. This information is converted, via Natural Language Processing, into a format that can be analyzed by a computer. Common patterns in these data can then be learned so that personalized suggestions and assistance can be conveyed to the user. However, concerns have been raised about gender bias in voice-assisted AI technologies that sound predominantly female, along with the costs of developing and implementing predictive algorithms, which may exclude some older adults from engaging with these digital platforms (World Health Organization, 2021).

Evidence suggests that AI algorithms could facilitate a better understanding of how to tailor notifications sent to users to encourage or "nudge" them to undertake exercise, as detailed analysis of prior use may lead to better insights about when, how often, and what kind of reminder messages should be sent to each individual user (Bidargaddi et al., 2018). Too few reminders and an older person may stop using a digital exercise program, while too many notifications may be burdensome and frustrate users leading to less adherence. Hence, machine learning techniques such as association rules are being employed to develop customized notification systems for mobile applications to alert users based on their personal preferences (Mehrotra et al., 2017). This approach could benefit older adults wishing to receive a variety of reminders about when and where to exercise, and how often and for how long to do this, to improve their fitness and reduce the occurrence of falls and any related injuries.

Intervention Adherence and Attrition

Digital health interventions can have a high attrition rate, where users log in and use a software application for a short period and then lose interest over time, along with any benefits the technology may bring (Eysenbach, 2005). Machine learning or other statistical models can be used to help reduce attrition by identifying users who are at risk of dropping out of a digital physical activity intervention in real time (Schleicher et al., 2022). Retrospective or prospective data on physical activity collected over several weeks or months from older users via their smartphone could provide insights into engagement and attrition (Guertler et al., 2015). These data sets could be analyzed via machine learning techniques to create a predictive model that would indicate if and when a person will stop using a digital intervention (Baglione et al., 2022). This would be important as older adults at risk of dropping out could be targeted with "anti-attrition" measures such as personalized reminders and other incentives to continue exercising. Yet, there are some older adults who experience barriers to accessing digital interventions due to low literacy levels, cost, lack of interest, usability, and other issues. Therefore, algorithmic bias, in which underrepresented groups (e.g., age, gender, race/ethnicity) are not adequately represented in the data set or its analysis, should be given due consideration when applying AI techniques to help prevent ageism (World Health Organization, 2022). While there are some simple solutions that reduce the impact of these problems, for instance, using data sets that accurately represent the diversity of older populations and the many factors that affect physical activity (Panch et al., 2019), this is an ongoing issue and area of active research in the AI community.

Physiological and Environmental Monitoring and Analytics

Physiological and remote monitoring is another area of physical activity where machine learning models may provide greater ability to accurately predict clinically relevant outcomes from data sets gathered via sensors (e.g., accelerometers); mobile devices (e.g., smartphones, tablet computers, pedometers); and electronic systems (e.g., video surveillance) in an older person's private home, a care home, or other residential setting. In many cases, predictive models using standard statistical models have been shown to be as good as machine learning alternatives (Christodoulou et al., 2019). However, the type of time series and visual data collected by sensors lends itself well to deep learning approaches, where relevant biomarkers (or features) that are not easy to identify from the raw data can be learned automatically. Recording digital data on an ongoing basis would allow for more fine-grained assessment of exercise and its impact on older adult health (Dallinga et al., 2018). But, the personal privacy of older people should be respected, as regular remote monitoring is not favored by some individuals, and so data should be collected and managed securely only when consent has been given, with an ongoing opt-out process that is quick and easy to follow. Therefore, codesigning these types of AI-based technologies with older people could enhance how they work while reducing some of the risks associated with them, as their needs and preferences would be considered (Blakey et al., 2020). Despite the limitations of AI, these novel computational approaches could further our understanding of physical activity in aging populations around the world and offer new insights into how we can support and encourage exercise among older adults and reduce falls via digital interventions.

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