Technology-assisted physical activity interventions for older people in their home-based environment: a scoping review

Rosemary Dubbeldam, Rafal Stemplewski, Juliia Pavlova, Magdalena Cyma-Wejchenig, Sunwoo Lee, Patrick Esser, Ellen Bentlage, Veysel Alcan, Özge Selin Çevik, Eleni Epiphaniou, Francesca Gallè, Antoine Langeard, Simone Gafner, Mona Ahmed, Niharika Bandura, Arzu Erden Güner, Evrim Göz, Ilke Kara, Ayşe Kabuk, Ilayda Türkoglu, Zada Pajalic, Jan Vindiš, Damjan Jaksic, Uğur Verep, Ioanna Chouvarda, Vera Simovska, Yael Netz, Jana Pelcova

Submitted to: JMIR Aging
on: August 25, 2024

Table of Contents

Technology-assisted physical activity interventions for older people in their home-based environment: a scoping review

Rosemary Dubbeldam[1*]; Rafal Stemplewski[2*]; Juliia Pavlova[3*]; Magdalena Cyma-Wejchenig[2*]; Sunwoo Lee[4*]; Patrick Esser[5*]; Ellen Bentlage[1*]; Veysel Alcan[6*]; Özge Selin Çevik[7*]; Eleni Epiphaniou[8]; Francesca Gallè[9]; Antoine Langeard[10]; Simone Gafner[11]; Mona Ahmed[1]; Niharika Bandura[12]; Arzu Erden Güner[13]; Evrim Göz[14]; Ilke Kara[15]; Ay?e Kabuk[16]; Ilayda Türkoglu[17]; Zada Pajalic[18]; Jan Vindiš[4]; Damjan Jaksic[19]; U?ur Verep[15]; Ioanna Chouvarda[20]; Vera Simovska[21]; Yael Netz[22*]; Jana Pelcova[4*]

[1]University Münster Institute for Sport and Exercise Sciences Münster DE
[2]University of Physical Education Department of Digital Technologies in Physical Activity Poznan PL
[3]Ivan Boberskyj Lviv State University of Physical Culture Department of Theory and Methods of Physical Culture Lviv UA
[4]Palacký University Olomouc Faculty of Physical Culture Olomouc CZ
[5]Oxford Brookes University Centre for Movement, Occupation and Rehabilitation Sciences Oxford GB
[6]Tarsus University Department of Electrical and Electronics Engineering, Faculty of Engineering Tarsus TR
[7]Mersin University Department of Physiology, Faculty of Medicine Mersin TR
[8]European university Cyprus School of Humanities, Social and Education Sciences Engomi CY
[9]University of Naples Department of Medical, Movement and Wellbeing Sciences Naples IT
[10]Normandy University, UNICAEN, INSERM, COMETE, CYCERON Caen FR
[11]HES-SO Valais-Wallis Institute of Health Sciences, School of Health Sciences Leukerbad CH
[12]Otto-Von Guericke Universität of Magdeburg Magdeburg DE
[13]Karadeniz Technical University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation Trabzon TR
[14]Tarsus University Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences Tarsus TR
[15]Dokuz Eylul University Department of Physical Therapy and Rehabilitation, Institute of Health Sciences Izmir TR
[16]Zonguldak Bülent Ecevit University Faculty of Health Sciences Zonguldak TR
[17]Health Sciences University, Hamidiye Faculty of Nursing Department of Fundamentals of Nursing ?stanbul TR
[18]VID Specialized University Faculty of Health Sciences Oslo NO
[19]University of Novi Sad Faculty of Sport and Physical Education Novi Sad RS
[20]Aristotle University of Thessaloniki Lab of Computing, Medical Informatics & Biomedical-Imaging Technologies, School of Medicine Thessaloniki GR
[21]HEPA Macedonia National Organisation for the Promotion of Health-Enhancing Physical Activity Skopje MK
[22]Wingate Institute The Levinsky-Wingate Academic Center Netanya IL
[*]these authors contributed equally

Corresponding Author:
Rosemary Dubbeldam
University Münster
Institute for Sport and Exercise Sciences
Horstmarer Landweg 62B
Münster
DE

Abstract

Technology-assisted physical activity interventions for older adults in their home-based environment have been used to promote physical activity. While previous reviews focused on health-related outcomes of such interventions, this scoping review explores the characteristics of the technology in relation to the characteristics of populations, exercise types and usability in terms of adverse events, drop-outs, adherence and user experience.

We identified 8496 sources. After title and abstract screening, 455 full texts were assessed, and 148 were included, representing 12,717 participants aged 74 (SD 6) years. In total, 93 (63%) sources reported on the population's health status. The main purpose of the interventions was balance (51%), and strength and power (43%) and intervention purposes were not related to embedded technology. In studies where the participant's health status was reported as healthy, 53% implemented exergames compared to only 27% in studies with participants with a clinical condition. Mobile apps (20%) and trackers (11%) were

implemented likewise in both groups. The technology was embedded to provide continuous exercise information (27%) and exercise feedback (27%) or to record real-time movement data (26%).
Adverse events were reported in 68 (46%) of the sources with three quarters (49 sources) reporting no adverse events. Only 2 mild events were related to technology. Dropout rates were reported in 100 (68%) studies, with no differences between intervention (16±16%) and control (14±12%) groups. Dropout reasons related to technology in 3%. Adherence was reported in 78 studies (53%) and was slightly higher in the intervention group (80±18%) compared to the control group (71±25%). A significantly higher adherence was found between interventions that were tailored (83 ± 15%) versus those that were not (75±21%). General enjoyment of the technology was captured in 55 studies (37%) and was rated positive (91%), neutral (7%) or negative (2%). Occasionally reported wishes were related to goal setting, feedback, technical support, exercise variation, and social setting.
In conclusion, various technologies were successfully used in healthy and clinical older populations. The embedded technology was not a reason for additional dropouts, lead to slightly better adherence, and adverse events were rarely related to technology. When assessed, the technology was well accepted and positively enjoyed.

(JMIR Preprints 25/08/2024:65746)
DOI: https://doi.org/10.2196/preprints.65746

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?
✔ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.
2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?
✔ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Technology-assisted physical activity interventions for older people in their home-based environment: a scoping review

Introduction

The benefits of physical activity in advanced age are well-documented, just as paradoxically is the increase in sedentary behaviour with increased age [1,2]. Additionally, even if individuals are motivated to engage in physical activity outside the home, environmental barriers such as weather conditions, infrastructure constraints, or specific constraints like COVID-19 can make it difficult for older adults to venture out [3,4]. This paradox has prompted clinicians to seek technological solutions to encourage older adults to be more physically active within their home environment.

Employed in the form of varied electronic devices, software or wearable technology such as smartphones [5], fitness trackers [6], mobile phone applications [7], tablets [8], virtual reality [9], exergames [10], E-coaching [11], and Robotics [12], technology has been reported to support beneficial changes in sedentary time and physical activity in the older adult population [13,14]. Previous research has reported that home-based physical activity interventions, supported by technology, benefit body composition, aerobic fitness, cognitive abilities and postural control, reducing the risk of falls, and maintaining regular physical activity among the older population [8,15,16]. However, while there are indications that older adults tend to show high levels of adherence to technology-assisted physical activity interventions [14], quite a few barriers limiting the use of this technology have been reported, such as functional barriers related to the design of e-health programs and their interface with older end users, or lack of technological support [17].

With the continuously increasing number of technology-assisted healthcare tools, particularly those for home-based physical activity, and the difficulties older adults face in adapting to and operating these tools, it is not surprising that several reviews have been conducted in recent years to examine the usability of technology-assisted physical activity programs [14,18–24], more than half of them in recent years – 2021-2024 [20–24]. Most of these reviews focussed on specific aspects [18–23], on assistive technologies in general [14,23,24] and, considering the boost of assistive-technology physical activity in the recent five years, some are relatively dated [14,19]. While a recent review by CostaBrita et al. elaborated on the usage of technology in home-based exercise among older community dwelling adults (80), focussing on the type and volume of the exercises, types of technology, aspects of the usage of technology (adherence, acceptance, feasibility), and health outcomes, that review did not elaborate on the participants included in the studies, the technology function and interface. Also, it did not explore or analyse specific aspects of technology such as design, function and interface of the technology as related to specific type of population or specific type of exercise, nor did they examine safety or adverse events aspects related to technology.

Aligned with the recommendations of the PhysAgeNet, a European Cooperation in Science and Technology (COST) network devoted to evidenced-based physical activity in old age [25] and with the proliferation of technology related to home-based physical activity, our aim in this scoping review was to explore the characteristics of that technology in relation to the characteristics of populations (e.g. health status) and exercise types. Furthermore, we aimed to examine the usability of that technology in terms of adverse events, drop-outs, adherence and the user experience (acceptability and enjoyment). This may promote the optimal utilization of technology to provide efficient home-based physical activity programs for older adults.

Methods

This scoping review was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for scoping reviews [25] and the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping reviews (PRISMA-ScR) checklist [26]. The protocol for the scoping review is available at the Open Science Framework Registries [27]. The review was conducted by an international interdisciplinary team of researchers with regular weekly meetings to discuss, distribute tasks and ensure consistency during the different steps of the process.

Eligibility

Sources were considered for inclusion if they met the following criteria: 1. participants aged on average 60 years and older; 2. studies that focused on technology-assisted physical interventions; and 3. studies based within home-based environments. Table 1 gives a detailed definition of the participants, concept, and context.

Sources were excluded if 1. the study design was a review or study protocol, or if the publication type was an abstract or non-peer-reviewed conference proceedings, 2. participants were on average younger than 60 years of age, 3. no physical activity intervention was present or the intervention took place within clinical setting, 4. digital technology was not present or not an integral part of the intervention, 5. the intervention did not take place in home-based setting, or 6. the study language was other than English.

Table 1: Details of the participants, concept and context (PCC framework) which form the basis for source

inclusion consideration.

PCC	Inclusion	Definitions/descriptions
Population	Older people	Older adults aged 60 years and older (the participant's group mean age should be ≥ 60 years), living independently or in residential facilities (aged care facilities).
Concept	Technology-assisted physical interventions	A physical intervention is a structured or unstructured measure taken to improve or maintain the user's physical activity and practised individually. It can be tailored to specific health or fitness goals (structured) or it can be general and not specifically prescribed by a health professional (unstructured) [28]. The intervention includes any form of physical activity such as human daily activities, exercise, training, or physical fitness training. The technologies used to deliver the intervention are digital systems and include, among others, mobile applications, telemedicine, wearable electronic devices, exergaming, and virtual reality. The delivery of the intervention can take place supervised, facilitated (partly supervised) or unsupervised.
Context	Home-based environment	The home-based location can be the home environment, i.e., the immediate vicinity of the community environment, i.e., a public open-access setting [28].
	Health status	People with or without mental or physical impairments.

Search strategy

According to JBI recommendation, an initial limited search of PubMed and Web of Science was conducted to identify potentially relevant key search terms for the PCC framework. In an iterative process, the keywords in the text of retrieved sources were analysed. The search terms provided were consulted with experts within the team to capture all relevant keywords and then grouped into four main headings: population group, residence, technology, and intervention. The search string was further expanded by running searches with Medical Subject Heading (MeSH Terms) as well as with adequate non-MeSH terms for databases that do (e.g., PubMed) or do not use a MeSH tree (e.g., Web of Science), respectively and cross-checked by a subject librarian at Oxford Brookes University.

The created search strings were the basis for developing a full search strategy in Medline (PubMed), Embase (Ovid), CINAHL (Ebsco), SportDiscus (Ebsco), and Web of Science and converted as necessary (Appendix 1). The database search was performed between the 26th of September and the 6th of October 2022. As a third step of the search strategy, an additional search was performed in the reference list of the identified sources selected from the full text search.

Source of evidence selection

Following the search, all identified sources were collated and uploaded into Rayyan [29], and duplicates were removed. Two reviewers performed a pre-screening pilot on 100 titles and abstracts to develop screening instructions. Any disagreements were resolved via consensus with the help of a third reviewer. After the whole team approved the final version of the screening instruction tool, the two reviewers screened the remaining titles and abstracts. Again, disagreements were resolved by a third reviewer.

Full texts of potentially eligible sources were uploaded into Rayyan. Ten different pairs of reviewers assessed these sources within Rayyan [29]. Disagreements were resolved via consensus in a team of five other (independent) reviewers. The results of the search, the sources' inclusion process, and exclusion reasons have been reported in full and presented according to the PRISMA flow diagram [26]. All sources obtained after the search process were stored in Mendeley (Mendeley Ltd., Elsevier).

Data extraction

A data extraction tool (Appendix 2) was made in line with the JBI guidelines [25,30] and a template for intervention description and replication (TIDieR) [31]. Five reviewers piloted the draft extraction tool, topic explanations were added to ensure the correct data was extracted into relevant columns and a final data extraction tool was prepared after which ten pairs of reviewers independently completed data extractions. When preparing the data for the analysis, a third reviewer cross-checked the extracted data and, where necessary, consulted the full text for details.

Data analysis and presentation

Four teams consisting of 3-5 reviewers analysed the extracted data regarding the following topics: study design, participants, interventions and outcome measures, and technologies and key findings. An inductive thematic analysis was conducted. Codes or labels were defined to categorise the data and a coding framework with definitions of the (sub)categories was developed. This coding framework allowed to characterise the (sub)populations of the participants (age, health status, mobility, country of residence, etc.), intervention (type, tailoring, temporal data, etc.), the used technologies (design, function, interface), participation (feasibility, effectiveness, safety, etc.) and health outcomes (physical and mental capacities, fall risk, quality of life, etc.). A detailed description of the coding framework is presented in Appendix 3. During the extracted data categorisation process, the reviewers came together regularly in their small teams to discuss discrepancies until consensus was achieved and all data categorised. For this review, the focus lies with the participants, intervention and especially the technology categories.

The quantitative and qualitative data were analysed descriptively using absolute and relative frequency, percentage, average, and standard deviation. Pie charts and bar charts were made to visualise results.

Crosstabulation statistical analysis was used to get a better understanding of what kind of digital technologies was used to integrate specific physical activity interventions programmes and for which populations. Observations between two or more nominal variables were explored, whereby the frequency of observations between variables was counted and reported accordingly and expressed as a percentage against all observations. Specifically, the cross-tabulation between the following categorical variables were conducted:

- Technology (design, function, interface) versus
  - Population (age group, health status, residency),
  - Intervention (type of exercise, tailoring).

Adherence and dropout rates were expressed as a percentage of the relevant study population and compared against population and intervention characteristics (two or more categories) using differential tests. In the case of a binominal category, an independent t-test was used. The following categories and linear outcomes were compared:

- Participation outcomes (dropouts, adherence) versus
  - Population (age groups, health status).
  - Intervention (group, tailoring, supervision)

Relationships between linear parameters were regressed to extract the coefficient of determination (R^2) with associated *p*-value to indicate it's significance. These were tested for the dropout and adherence outcomes, against the total number of intervention sessions and session durations.

Results

Source selection

A total of 12,512 sources were identified during searching in Medline (PubMed), Embase (Ovid), CINAHL (EBSCO), SportDiscus (EBSCO), and Web of Science databases. After screening, 148 articles remained. Inclusion and exclusion details can be found in the PRISMA flowchart (Figure 1) with further details on a source-by-source basis in the supplementary details.

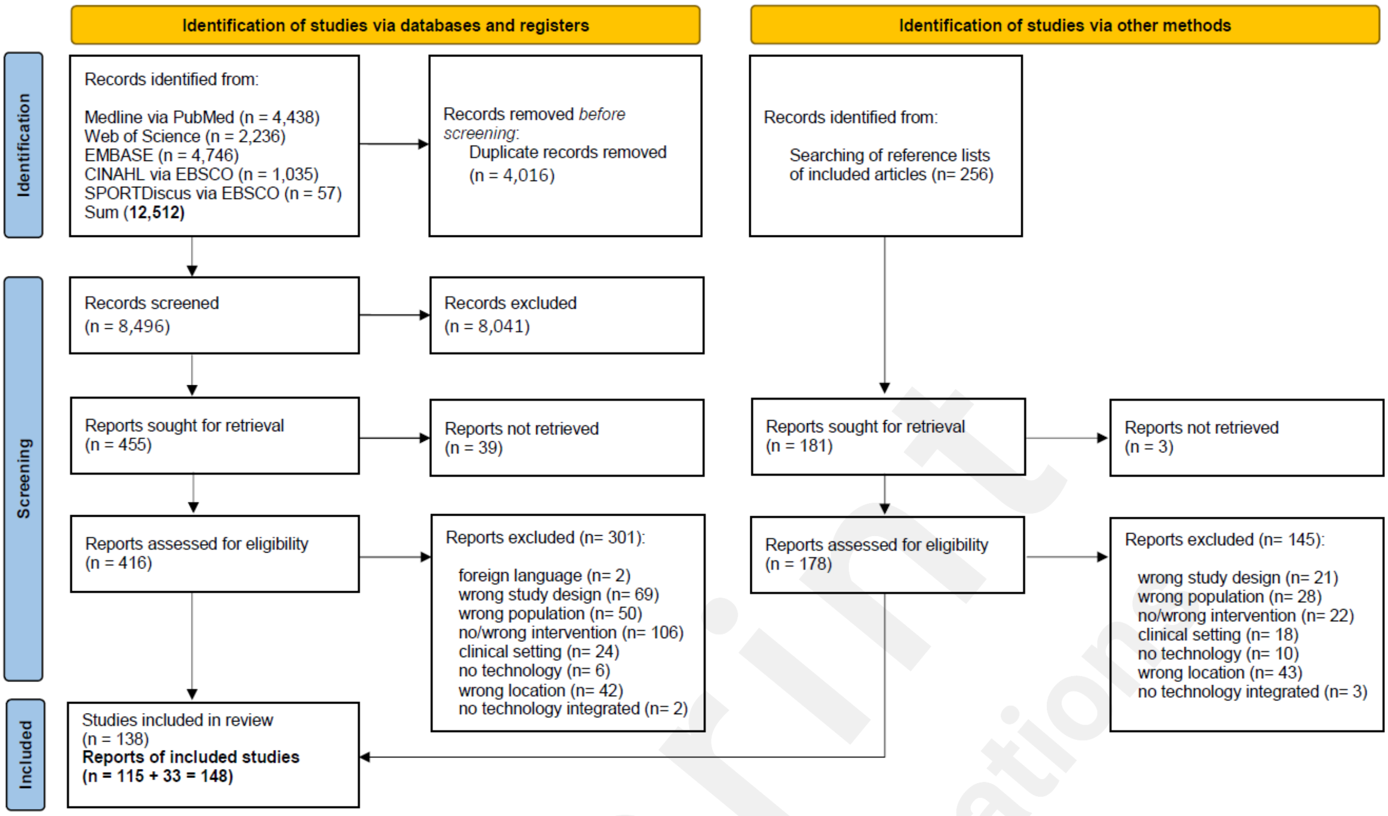
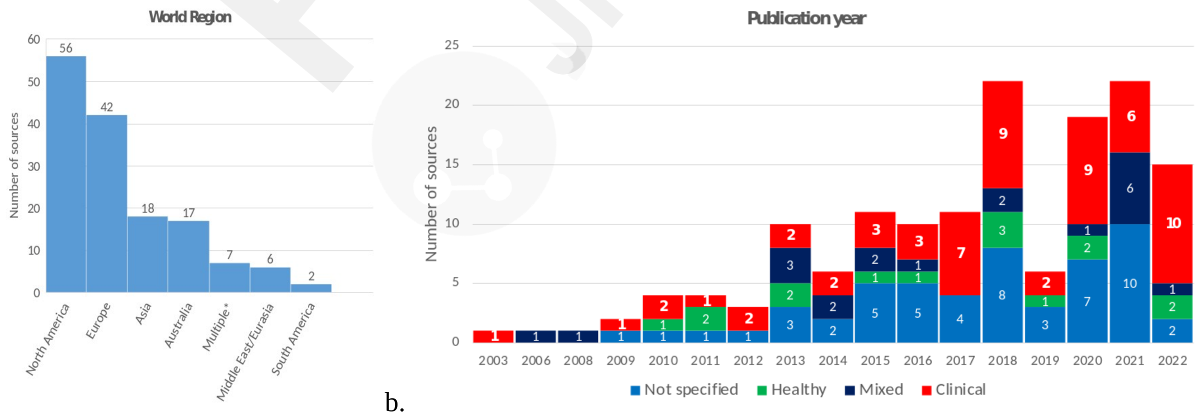


Fig 1.: Flowchart search process

Study characteristics

Publication years ranged from 2003 to 2022, with most of the included sources published in the last five years (N=84, 57%). An overview of the number of sources performed by region and publication year is presented in Figure 2.



a. b.

Figure 2: a. Number of included sources by world region. b. and by publication year and health status.

The sources included 75 (51%) Randomized Controlled Trials, 35 (24%) pre-post-test, and 17 (12%)

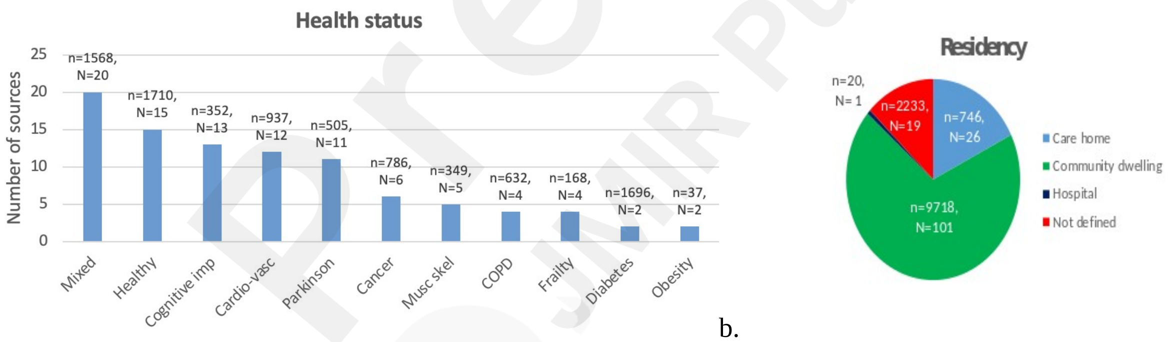
feasibility studies and to a lesser extent qualitative studies (N=6; 4%), non-randomized controlled trials (N=5; 3%), experimental studies (N=5; 3%), mixed methods (N=4; 3%), and one case study (N=1; 1%).

Participant characteristics

The included sources contained a total sample of 12,717 participants, aged 74 (SD 6) years on average, with a range of 60-88 years. Most sources were devoted to youngest-old group (N=87, 59%), followed by middle-old (N=51, 35%) and oldest-old group (N=6, 8%). A small sample of sources reported on mixed (N=2, 1%) age categories. In two studies, the age of the participants was not reported. With increasing age groups, the percentage women increased from 51% (youngest-old) to 68% (middle-old) and 78% (old-old).

A larger focus on the clinical population is visible since 2017, although the health status is not always properly reported (fig.2b). A total of 93 sources (63%) reported on the population's health status (Fig. 3a). In 55 (37%) sources, information on comorbid conditions was indicated, the average number of comorbidities was 4.2 (SD 2.6; range 1-10).

Most sources (N=101, 68%) included participants living in community-dwelling residences, while 19 sources (13%) were not specific on participant living arrangements (Fig. 3b).



a. b.

Figure 3: Number of included sources (N) by reported a. health status and b. residency. With n being the total number of participants with cardio-vascular disease (Cardio-vasc); cognitive impairments (Cognitive imp); chronic obstructive pulmonary disease (COPD) and musculoskeletal disease (Musc skel).

Prior experience with technology was stated in 16% (N=24) of sources, and 15% (N=22) of sources stated that participants had access to technology at home prior to the implementation of the intervention. Seven sources (5%) highlight information about the prior frequency of **use** of these services or devices.

Intervention design characteristics

In 66 studies, participants received supervised interventions (professional or non-professional) with a further 83 studies including unsupervised interventions. Additionally, one source tested supervised vs unsupervised technology-based interventions.

In most of the sources (N=93, 63%), the intervention was tailored to individuals and or groups of participants. The other 55 sources (37%) applied a generic intervention approach to all participants. In the tailored interventions, exercises were adapted to the participant's specific needs, or the progression of the exercises was personalised by adapting the difficulty, intensity or frequency level of the exercises. Furthermore, individual assessments and feedback systems allowed for continuous adjustment of exercises based on performance.

Intervention durations varied from one week up to 288 weeks (Fig. 4a). Two interventions (1%) did not report intervention duration. Session duration varied by study from 5 minutes up to 120 minutes (Fig. 4b). Session frequency was reported in 119 studies and ranged between 1 to 21 per week. In two studies, the weekly session frequency could be chosen independently. Most sources (N=87, 59%) ranged from 1 to 3 sessions per week.

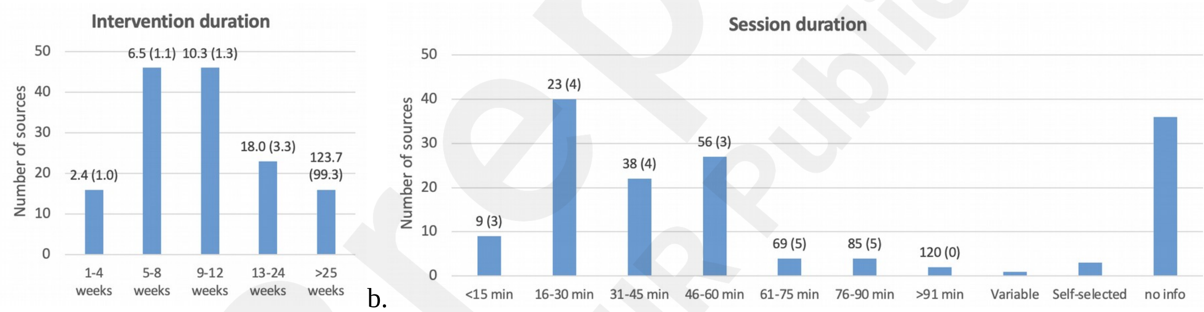
a.


Figure 4: Number of sources stratified by a. intervention duration (average and SD) and b. session duration (average and SD). For intervention duration in minutes (min), the average duration and corresponding standard deviation per group is also presented.

Exercise intensity was described in only 20 (14%) sources. Of these, five (3%) used Rate of Perceived Exertion, three (2%) the Borg scale with a further nine sources (6%) reported intensity in a different manner, e.g., the level of the exercise game. Only one study (1%) set the intensity at 60% of Heart Rate Reserve, with another 2 (1%) using self-pacing of intensity.

146 sources (97%) reported a total of 298 different exercise types as part of the interventions. In these interventions, the top five purpose(s) of the exercise or physical activity were balance (N=75, 51%), muscular strength and power (N=64, 43%), cardiorespiratory fitness (N=30, 20%), functional mobility (N=28, 19%) and general physical activity (N=25, 17%). In 58 (40%) sources, the focus was on one type of exercise, whereas the majority (N=88, 59%) used combinations of exercises with

on average 3 (min 2, max 5) types of exercises. Two sources did not report on the exercise type used as part of the intervention.

Technology Characteristics

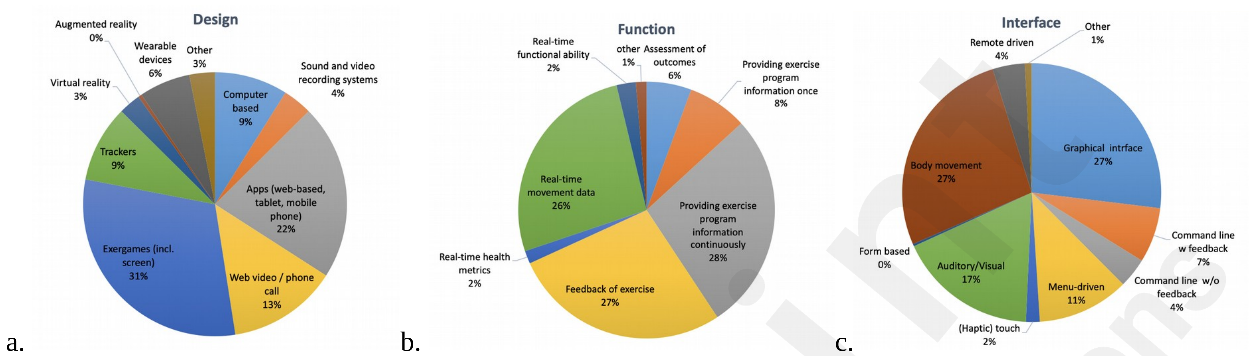


Figure 5: Extracted parameter count (in % of sources) for a. technology design, b. function and c. interface categories.

An overview of the technology designs, functions and interfaces used in the sources is given in figure 5. Below results of the cross-tabulation between technology and population or intervention characteristics are described. All detailed results can be found in Appendix 4.

Technology * Population

The results of the cross-tabulation between participant characteristics and technology design are presented in table 2. The cross-tabulation results between participant characteristics and technology function and interface can be found in Appendix 4. Exergames were implemented in half of the sources with oldest-old adult participants who are aged 85 years and older. In the sources with middle-old age groups (75-85 years), exergames (33%) and mobile apps (21%) were both frequently used and alternative designs such as web/video phone call (13%) were implemented as well. In sources with youngest-old age groups (60-74 years), trackers (14%) were more often implemented than in the middle-old or oldest-old age groups (3% and 6% respectively). In sources where the participant’s health status was reported as healthy, 53% implemented exergames compared to only 27% in sources with participants with a clinical condition. For both health status groups, mobile apps (20%) and trackers (11%) were likewise implemented. However, sources with participants with a clinical condition also made use of other technological designs such as computer based (11%), web video/phone call (15%) or wearable devices (8%). Age and health status did not influence the technological functions or user interface.

In community setting studies, exergames (26%) and apps (24%) were equally deployed. However, in care homes half of the sources used exergames. Wearable technology was used frequently in settings where residency was unfortunately not specified, whereas the use of web video/phone call designs was highest (relatively) in community setting studies. Making use of specific functions and interfaces was similarly distributed for community dwelling and care home residents. Only the body movement interface was 35% in care home compares to 24% in community settings, probably related to the implemented exergames.

Table 2: Cross-tabulation results for participant characteristic age, health status and residency versus technology design.

AGE / DESIGN	Sum*	Computer based	Sound/ video record. systems	Mobile Apps	Web/ video phone call	Exer-games	Track-ers	Virtual reality	Aug-mented reality	Wear-able devices	Other
Youngest old (65-74 y)	125	7%	2%	24%	15%	25%	14%	2%		6%	4%
Middle old (75-85 y)	75	11%	7%	21%	13%	33%	3%	4%		7%	1%
Oldest old (> 85+ y)	18	11%	6%	11%	6%	50%	6%			6%	6%
Mixed	3					67%			33%		
HEALTH STATUS											
Healthy	19			21%	5%	53%	11%	5%			5%
Clinical condition	127	11%	5%	19%	15%	27%	11%	2%		8%	3%
RESIDENCY											
Care Homes	42	10%	5%	7%	2%	50%	7%	10%		2%	7%
Community Dwelling	153	9%	3%	24%	18%	26%	10%	1%	1%	5%	3%
Hospital	1						100%				
Other	33	6%	3%	24%	6%	21%	3%	18%		18%	

*The horizontal rows add up to 100% of the sum in second column. The other columns represent the percentages of the sum, and the total of each row equals 100%. With abbreviations: Apps, applications; cmnd, command; record., recording; y, years.

Technology * Intervention

The results of the cross-tabulation analyses for intervention type and technology are presented in appendix 4. Exergame and mobile app designs were used to achieve improvements for a large range of physiological parameters such as balance, muscle strength, functional mobility or cardiovascular. Similar for web video/phone calls, but these technologies were incorporated into the sources to much lesser amount. Exergames were predominantly used to train cardiorespiratory fitness (41%), neuromotor function (48%), mental and cognitive function (50%), and fall reduction (57%). Only enhancement of physical activity was trained most using trackers (33%, e.g., for step counting). For all exercise types, the technologies provided continuous exercise information, feedback and assessed real time movement data. These technological functions were achieved through graphical (25-30%), body movement (20-36%), or auditory and visual (13-23%) interfaces with the users.

Incorporating **tailoring** of the intervention exercise or activity did not seem to influence the technology design, function of user interface.

Outcome Measurements

Adverse Events

A total of 68 sources (46%) reported information on adverse events. Out of these, 49 (72%) sources reported no adverse events, with the other 19 sources reporting a total of 78 adverse events (n=78, 100%) categorised in grade 1 (mild, n=40, 51%), grade 2 (moderate, n=10, 13%), grade 3 (severe, n=28, 36%) events, with none reported in grade 4 (life-threatening) or grade 5 (death).

Of these 78 adverse events, 47 events (60%) could be related to the intervention and included 37 mild events, e.g., primarily musculoskeletal pain in joints, 8 moderate events, e.g., rib fracture or COPD-related, and 2 severe events, e.g., severe injury due to (bicycle) fall accident. Only 2 adverse events were related to technology and included mild impairments from a skin rash due to Fitbit wearing and nausea due to the Virtual Reality environment.

Dropout and Adherence

Information on dropout and adherence for the intervention groups was reported in 100 sources (68%) and 79 sources (53%), respectively. Information on dropout and adherence for the control groups was reported more sparely in 45 sources (47%) and 16 sources (17%), respectively. Whilst the number of participants for all sources are variable, dropout rates of control groups (13.9 ± 11.5%) and intervention groups (16.4 ± 15.6%) were similar ($t(34) = -0.648$, $p = 0.521$). Average adherence tended to be lower in the control groups (71.2 ± 25.1%) compared to the intervention groups (80.0 ± 18.4%) though this could not be tested statistically due to underreporting in the control group.

In total, the dropout reasons for 815 participants were quantitatively reported. Reasons for dropout were mostly health-related (28%), though these were unrelated to the intervention. Furthermore, dropout participants mentioned time-related issues (17%), such as lack of time or traveling and burden or motivation related issues (15%) such as lost interest or feeling burdened. Often another reason (17%) was indicated for the dropout, or no reason was mentioned at all (15%). About 5% of the dropout participants was lost due to follow-up issues ascribed to e.g., loss of contact or moving. Only 3% of the dropouts were related to technology: e.g., broken computer, internet malfunctioning, lack of device or space.

No differences (t(98)=-1.209, p= 0.115, d=-0.252) were found in dropout when interventions were tailored (15 ± 16%) or not tailored (19 ± 14%). A significantly higher adherence (t(77)=1.995, p=0.025, d=0.455) was found between interventions that were tailored (83 ± 15%) versus those that were not (75±21%). On the contrary, no differences were observed when comparing supervised versus unsupervised interventions, when assessing dropout (t(98)=-1.374, p=0.086, d=-0.275) and adherence (t(77)=0.606, p=0.273, d=0.136).

Sources including participants with reported clinical conditions as health status (17.7 ± 11.3% dropout), reported a similar level of dropout rate compared to those who used healthy populations (17.3 ± 18.2% dropout), which was non-significant (t(62)=0.063, p=0.475, d=0.022). There were no differences between adherence rates when comparing the sources with reported healthy participants versus participants with a reported clinical condition (t(48)=0.027, p=0.489, d=0.010). Differential testing between age groups was not possible, due to the low reported dropout ratios across three age-categories, although no trends were observed of dropout rate differences across age categories.

No further relationships were found between dropout or adherence, when regressing against the total number of intervention sessions (R^2 =0.012, p=0.924) or session duration (R^2=0.001, p=0.850).

User Experience

A total of 55 sources (37%) explored the general enjoyment of the technology part of their intervention. An overwhelming 91% reported a positive experience, with a vast minority reporting a neutral or negative experience (7% and 2% respectively).

Only 21 sources (14%) investigated the system usability. The system usability was reported using the System Usability Scale (SUS, N=12, 8%) or other questionnaires, mostly using Likert scales or percentages (N= 9, 6%). The reported SUS values ranged from 62 to 90 with an average of 77 (SD 9) indicating okay, good and excellent overall user friendliness [32]. In several sources (N=2) it was reported that the SUS was assessed but then the result was not presented.

Regardless of the study design, wishes and needs of the users were seldom (systematically) assessed. When reported, the wishes were related to goal setting, feedback (regarding own or other participants performance, messages), support (technical, medical), the exercises (variation, choice of level), the technology (access, comfort, malfunctioning, touch screen), and social setting (in groups, partnering up, avatar look, timing).

DISCUSSION

This scoping review examines the feasibility and acceptability of digital technologies used in home-based physical activity interventions for older adults living in the community and in care-homes. Analysing 148 studies, the review finds that technologies like exergames and mobile apps are widely applicable and easy to use across diverse older adult populations, including healthy and those with clinical conditions. These technologies offer continuous features like exercise programs, feedback, and real-time movement tracking, addressing various goals such as balance, strength, functional mobility, and cardiovascular fitness. Interestingly, technology use did not lead to higher dropout rates, and adherence was significantly higher in tailored interventions. Adverse events directly related to the technology were rare. User evaluations indicated positive feedback regarding the usability and enjoyment of the technology, suggesting its potential to increase physical activity engagement among older adults.

Participants

Our research underscores the growing evidence of technology-based exercise and physical activity interventions in home-based environments (community dwelling and care-homes) since 2010, with a notable increase over the past five years [33]. Our review revealed that technology-assisted physical activity interventions have been explored among older adults in various age groups and with various health conditions. Given the increasing prevalence of age-related diseases and chronic health conditions among older adults, technology holds promise in promoting physical activity engagement, particularly among those with health challenges [20,21].

We found limited information on technology familiarity, e-literacy, and home access. This lack of information could pose challenges in tailoring interventions to individual needs and preferences [34–36]. Many studies also fail to report participants' education (only 40 %) and socio-economic status (only 9 %), which are critical factors as lower education often correlates with lower e-literacy and technology adoption rates [34,36]. This raises concerns about sample bias and the generalizability of results.

Interventions

This scoping review reveals significant diversity in technology-assisted intervention designs, supervision levels, and tailoring. The variability in intervention durations and session lengths and frequencies underscores the lack of standardisation in these interventions. Moreover, the underreporting of exercise intensity poses a significant challenge, with only 14% of sources detailing exercise intensity using varied methods. This is unexpected since technology can easily track and report intensity, providing both motivation and precise data for older adults. For instance, studies using Kinect systems and wearables like Fitbit have shown potential in accurately tracking exercise intensity, enhancing engagement and usability [37–39].

Technologies

In the sources we reviewed, exergaming emerged as the most used approach, featuring 53% of interventions for healthy populations and 27% for clinical groups. Despite most exergaming applications targeting younger populations [40,41], our scoping review identifies a significant shift towards older users, with exergames implemented in half of the sources involving participants aged 85 and above. The findings support and build upon previous research suggesting the utility of exergames in promoting physical activity, cognitive enhancement, and overall well-being in the older population [10]. Furthermore, the diversity of exergame interventions contents highlights a comprehensive strategy for addressing age-related challenges such as cardiorespiratory fitness (41%), neuromotor functions (48%), mental and cognitive abilities (50%), and reducing falls (57%).
Our findings also indicate that while exergames and mobile applications are the primary technologies used in these physical activity interventions, web video and phone call technologies or wearable devices also play a role, albeit less prominently. Especially in the clinical population, more often other designs than exergames were used compared to the interventions performed with healthy older adults. These other forms of technology design, offering a more passive interaction than the dynamic engagement found in exergames, may not be as prevalent but are nonetheless vital. Older, or more prone older adults may prefer and benefit from their easy set-up and simple usage [42–44]. Their integration highlights their significance within a comprehensive technological intervention framework, which aligns with effective telehealth components like text messaging for education and reminders, web-based content for goal-setting, and interactive platforms for health data exchange [45] .

In advocating for the integration of technology in physical activity interventions, our review highlights the pivotal role of technology functions and user interfaces, as supported by Bentlage et al. (2023), who stress their essential contribution to improve the activation factors skills, knowledge and motivation, yielding effective behavioural change [23]. We pointed out the primary technological functions as the continuous provision of exercise program information (28%), exercise feedback (28%), and the recording of real-time movement data (26%). Such continuous exercise information offers users an immersive, enjoyable and engaging experience [46],_fosters regular exercise habits [47], can facilitate the visualization of their movements and significantly increase their motivation [48]. Enhancing user engagement and overcoming engagement barriers can be achieved by using advanced technology to incorporate different user interfaces, preferably multiple types [23,49]. While graphical or body movement interface were prevalent in many sources (each 63%), alternative user interfaces were limited, i.e., 41% visual/auditory, 27% menu driven, 16% command line.

Notably, the tailoring of intervention exercises or activities did not significantly influence the choice of technology design, function, or user interface. This might indicate that the deployed technological solutions are versatile and adaptable across various intervention needs without requiring significant modifications [50,51]. Moreover, our review emphasizes a shift towards personalized interventions tailored to individual or group needs, with 63% of interventions adopting this approach (versus 37 % with a generic approach). This shift aligns with emerging evidence suggesting the effectiveness of personalized strategies in promoting adherence and achieving positive health outcomes among older adults [52].

Technology related outcomes

Technology engagement and adherence to protocols are tightly linked to the usability, enjoyment and effectiveness of exercise-based interventions [54]. Yet only a slight majority of studies reported on dropout and adherence rates, whereas an even smaller number reported on reasons for dropout or (reduced) adherence. Despite the Consolidated Standard of Reporting Trails (CONSORT) [55] statement and TIDieR (Template for Intervention Description and Replication) [56] guidelines dating back to 2010 and 2014, and the relevant *Standard Protocol Items: Recommendations for Interventional Trials* (SPIRIT) 2022 extension [57], there is still a lack of consistency of reporting.
Sources that reported the reasons for dropout among participants primarily cited health-related issues, with only a few instances attributed to technology usage, underscoring the older participants' willingness and engagement with home-based exercise technology. Such instances of technology-related dropout (3%) were predominantly due to technological failures, connectivity issues, or general disinterest. These findings are consistent with recent studies, which also identified a lack of

motivation and low familiarity with technology as key barriers to its implementation in older adults [14,24,58]. Furthermore, tailored interventions resulted in significantly higher adherence than control interventions. This underscores it is imperative to adapt the technology to the preferences and needs of the target aging population [22,24,42–44,59–61].

Strengths and limitations of this scoping review

Adopting a common vocabulary and definition of terms is challenging in research on technology-assisted physical activity interventions, which can be the intersection of medicine, physiotherapy, engineering and informatics, sensor and gaming technology, and even psychology and social sciences. Though challenging, we discussed and agreed upon definitions and vocabulary usage at each phase of the review. Furthermore, multiple protocols and double-blind scoring were incorporated in most phases of the review process to ensure consistency [62].

Regarding the included sources, most of the reviewed studies were from highly developed and advanced countries. In addition, the sources included in this scoping review, often failed to describe the used technology in sufficient detail to allow for replication of the design, function and or user interface. For example, exergames rely on an often bilateral interaction between the user and the system. However, the inputs (e.g. handheld devices, sensors, video cameras) are poorly described on how these were adapted for use. Valenzuela et al. (2018) explored older adults' experiences using an interactive cognitive-motor step training programme [63]. Yet, there is no clear description of how the interface has been adapted for their specific user group. Other sources assumed prior or even in-depth knowledge of commercial exergaming setups used within the intervention, avoiding interpretation of the data or replicability due to unknown use of commercial games (Wii-Fit), body movement recognition through three-dimensional camera setups (Xbox Kinect), or not clearly described engagement elements of online video calling for exercise class delivery (e.g. Yoga via Zoom calls) [64,65] .

This review has been carried out in a systematic and transparent manner [66]. However, we have not conducted a quality assessment or risk of bias of the included sources. Therefore, we cannot use the results of the included sources to draw significant conclusions on intervention effects on health outcomes.

Moving forward, future research should prioritize transparent reporting. The participant's health status including co-morbidities, mental and physical impairments and activity level, as well as technology experience should be recorded. The intervention design including type, duration, intensity, supervision, and tailoring should be well described. The technology design, functions (including consideration of behavioural change techniques) and user interface should be described in detail. Lastly, intervention and technology related outcomes such as drop-out, adherence, adverse events, and feedback on user experience should be reported. Guidelines for the development of technology-assisted physical activity interventions in older adults with various health conditions may lead to conformity, could contribute to better designs engaging older adults. Such guidelines may improve the effectiveness of the interventions and make studies better comparable by adequate reporting. The latter results in a deeper understanding of user preferences and advances the development of tailored technology-assisted interventions.

CONCLUSIONS

The review suggests that using technology in physical activity interventions is feasible for older adults in community dwellings and care homes, without additional risks of adverse events or dropouts. Furthermore, generally higher adherence was reported in technology-assisted interventions, which was significantly higher where interventions were tailored. Interventions were delivered to all older age groups, as well as those with and without clinical conditions and in a wide range of physical activity topics. The technology approaches for home-based exercise interventions, was found to be safe and enjoyable for older adults with acceptable usability. Despite the large number of sources that have been identified in this article, the lack of standardised reporting limited a more in-depth analysis of the main research question. Therefore, there is a need to update reporting guidelines for technology-specific interventions in this area.

References

1. World Health Organization. WHO guidelines on physical activity and sedentary behaviour. 2020. Available from: https://www.who.int/publications/i/item/9789240015128

2. Vogel T, Brechat P-H, Leprêtre P-M, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. International Journal of Clinical Practice 2009 Feb;63(2):303–320. doi: 10.1111/j.1742-1241.2008.01957.x

3. Aubertin-Leheudre M, Rolland Y. The importance of physical activity to care for frail older

adults during the COVID-19 pandemic. Journal of the American Medical Directors Association Elsevier; 2020;21(7):973–976.

4. Bosco A, McGarrigle L, Skelton DA, Laventure RME, Townley B, Todd C. Make Movement Your Mission: Evaluation of an online digital health initiative to increase physical activity in older people during the COVID-19 pandemic. Digital Health 2022;8. doi: 10.1177/20552076221084468

5. Sohaib Aslam A, van Luenen S, Aslam S, van Bodegom D, Chavannes NH. A systematic review on the use of mHealth to increase physical activity in older people. Clinical eHealth 2020;3:31–39. doi: 10.1016/j.ceh.2020.04.002

6. Shin G, Jarrahi MH, Fei Y, Karami A, Gafinowitz N, Byun A, Lu X. Wearable activity trackers, accuracy, adoption, acceptance and health impact: A systematic literature review. Journal of Biomedical Informatics Elsevier; 2019;93(October 2018):103153. PMID:30910623

7. Yerrakalva D, Yerrakalva D, Hajna S, Griffin S. Effects of mobile health app interventions on sedentary time, physical activity, and fitness in older adults: Systematic review and meta-analysis. Journal of Medical Internet Research 2019;21(11):1–13. PMID:31778121

8. Delbaere K, Valenzuela T, Woodbury A, Davies T, Yeong J, Steffens D, Miles L, Pickett L, Zijlstra GAR, Clemson L, Close JCT, Howard K, Lord SR. Evaluating the effectiveness of a home-based exercise programme delivered through a tablet computer for preventing falls in older community-dwelling people over 2 years: Study protocol for the Standing Tall randomised controlled trial. BMJ Open 2015;5(10):1–9. PMID:26493461

9. Dermody G, Whitehead L, Wilson G, Glass C. The role of virtual reality in improving health outcomes for community-dwelling older adults: Systematic review. Journal of Medical Internet Research 2020;22(6). PMID:32478662

10. Kappen DL, Mirza-Babaei P, Nacke LE. Older Adults' Physical Activity and Exergames: A Systematic Review. International Journal of Human-Computer Interaction 2019;35(2):140–167. doi: 10.1080/10447318.2018.1441253

11. Chatterjee A, Gerdes M, Prinz A, Martinez S. Human coaching methodologies for automatic electronic coaching (eCoaching) as behavioral interventions with information and communication technology: Systematic review. Journal of Medical Internet Research 2021;23(3):26–27. PMID:33759793

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

13. Stockwell S, Schofield P, Fisher A, Firth J, Jackson SE, Stubbs B, Smith L. Digital behavior change interventions to promote physical activity and/or reduce sedentary behavior in older adults: A

systematic review and meta-analysis. Experimental Gerontology Elsevier; 2019;120(January):68–87. PMID:30836130

14. Valenzuela T, Okubo Y, Woodbury A, Lord SR, Delbaere K. Adherence to technology-based exercise programs in older adults: a systematic review. Journal of Geriatric Physical Therapy Wolters Kluwer; 2018;41(1):49–61.

15. Langeard A, Bigot L, Maffiuletti NA, Moussay S, Sesboüé B, Quarck G, Gauthier A. Non-inferiority of a home-based videoconference physical training program in comparison with the same program administered face-to-face in healthy older adults: the MOTION randomised controlled trial. Age and Ageing 2022 Mar 1;51(3):afac059. doi: 10.1093/ageing/afac059

16. Lee J, Jung D, Byun J, Lee M. Effects of a combined exercise program using an iPad for older adults. Healthcare Informatics Research Korean Society of Medical Informatics; 2016 Apr;22(2):65–72. doi: 10.4258/hir.2016.22.2.65

17. Wilson J, Heinsch M, Betts D, Booth D, Kay-Lambkin F. Barriers and facilitators to the use of e-health by older adults: a scoping review. BMC Public Health 2021 Dec;21(1):1556. doi: 10.1186/s12889-021-11623-w

18. McGarrigle L, Boulton E, Todd C. Map the apps: a rapid review of digital approaches to support the engagement of older adults in strength and balance exercises. BMC Geriatrics BMC Geriatrics; 2020;20(1):1–11. PMID:33208117

19. Skjæret N, Nawaz A, Morat T, Schoene D, Helbostad JL, Vereijken B. Exercise and rehabilitation delivered through exergames in older adults: An integrative review of technologies, safety and efficacy. International Journal of Medical Informatics 2016 Jan;85(1):1–16. doi: 10.1016/j.ijmedinf.2015.10.008

20. BATALIK L, FILAKOVA K, SLADECKOVA M, DOSBABA F, SU J, PEPERA G. The cost-effectiveness of exercise-based cardiac telerehabilitation intervention: a systematic review. European Journal of Physical and Rehabilitation Medicine 2023 Apr;59(2). doi: 10.23736/S1973-9087.23.07773-0

21. Yang Y, Li S, Cai Y, Zhang Q, Ge P, Shang S, Han H. Effectiveness of telehealth-based exercise interventions on pain, physical function and quality of life in patients with knee osteoarthritis: A meta-analysis. Journal of clinical nursing 2023 Jun;32(11–12):2505–2520. PMID:35872635

22. Piech J, Czernicki K. Virtual Reality Rehabilitation and Exergames—Physical and Psychological Impact on Fall Prevention among the Elderly—A Literature Review. Applied Sciences 2021 Apr 30;11(9):4098. doi: 10.3390/app11094098

23. Bentlage E, Nyamadi JJ, Dubbeldam R. The Importance of Activating Factors in Physical Activity Interventions for Older Adults Using Information and Communication Technologies: Systematic Review. JMIR mHealth and uHealth JMIR Publications Inc., Toronto, Canada; 2023;11(1):e42968.

24. Raquel Costa-Brito A, Bovolini A, Rúa-Alonso M, Vaz C, Francisco Ortega-Morán J, Blas Pagador J, Vila-Chã C. Home-based exercise interventions delivered by technology in older adults: A scoping review of technological tools usage. International journal of medical informatics 2024 Jan;181:105287. PMID:37972483

25. Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, McInerney P, Godfrey CM, Khalil H. Updated methodological guidance for the conduct of scoping reviews. JBI Evidence Synthesis 2020;18(10):2119–2126. PMID:33038124

26. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, MacDonald MT, Langlois E V., Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Annals of Internal Medicine 2018;169(7):467–473. PMID:30178033

27. Dubbeldam R, Stemplewski R, Cyma-Wejchenig M, Esser P, Ahmad M, Bentlage E, Pavlova I, Alcan V, Netz Y, Lee S, Pelclova J, Brach M. Scoping review on technology-assisted physical interventions for older people in their home environment. 2023; doi: 10.17605/OSF.IO/NVECQ

28. Denton F, Power S, Waddell A, Birkett S, Duncan M, Harwood A, McGregor G, Rowley N, Broom D. Is it really home-based? A commentary on the necessity for accurate definitions across exercise and physical activity programmes. International Journal of Environmental Research and Public Health 2021;18(17). PMID:34501833

29. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Systematic Reviews Systematic Reviews; 2016;5(1):1–10. PMID:27919275

30. Pollock D, Peters MDJ, Khalil H, McInerney P, Alexander L, Tricco AC, Evans C, de Moraes ÉB, Godfrey CM, Pieper D, Saran A, Stern C, Munn Z. Recommendations for the extraction, analysis, and presentation of results in scoping reviews. JBI Evidence Synthesis 2023 Mar;21(3):520–532. doi: 10.11124/JBIES-22-00123

31. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, Altman DG, Barbour V, Macdonald H, Johnston M, Kadoorie SEL, Dixon-Woods M, McCulloch P, Wyatt JC, Phelan AWC, Michie S. Better reporting of interventions: Template for intervention description and replication

(TIDieR) checklist and guide. BMJ (Online) 2014;348(March):1–12. PMID:24609605

32. Bangor A, Kortum PT, Miller JT. An empirical evaluation of the system usability scale. International Journal of Human-Computer Interaction 2008 Jul 29;24(6):574–594. doi: 10.1080/10447310802205776

33. Pajalic Z, de Sousa DA, Strøm BS, Lausund H, Breievne G, Kisa S, Saplacan D, Larsen MH, Jøranson N. Welfare technology interventions among older people living at home—A systematic review of RCT studies. PLOS Digital Health 2023 Jan 24;2(1):e0000184. doi: 10.1371/journal.pdig.0000184

34. Wang X, Luan W. Research progress on digital health literacy of older adults: A scoping review. Frontiers in public health 2022;10:906089. PMID:35991040

35. Choi NG, Dinitto DM. The digital divide among low-income homebound older adults: Internet use patterns, eHealth literacy, and attitudes toward computer/Internet use. Journal of medical Internet research 2013 May;15(5):e93. PMID:23639979

36. Estrela M, Semedo G, Roque F, Ferreira PL, Herdeiro MT. Sociodemographic determinants of digital health literacy: A systematic review and meta-analysis. International journal of medical informatics 2023 Sep;177:105124. PMID:37329766

37. Knippenberg E, Timmermans A, Palmaers S, Spooren A. Use of a technology-based system to motivate older adults in performing physical activity: a feasibility study. BMC Geriatr 2021 Dec;21(1):81. doi: 10.1186/s12877-021-02021-3

38. VandeBunte A, Gontrum E, Goldberger L, Fonseca C, Djukic N, You M, Kramer JH, Casaletto KB. Physical activity measurement in older adults: Wearables versus self-report. Front Digit Health 2022 Aug 31;4:869790. doi: 10.3389/fdgth.2022.869790

39. Matsuura H, Mukaino M, Otaka Y, Kagaya H, Aoshima Y, Suzuki T, Inukai A, Hattori E, Ogasawara T, Saitoh E. Validity of simplified, calibration-less exercise intensity measurement using resting heart rate during sleep: a method-comparison study with respiratory gas analysis. BMC Sports Sci Med Rehabil 2019 Dec;11(1):27. doi: 10.1186/s13102-019-0140-x

40. Abaya J. Effects of exergaming on health and fitness outcomes for students with disabilities: a meta-analysis. 2023;

41. Benzing V, Schmidt M. Exergaming for Children and Adolescents: Strengths, Weaknesses, Opportunities and Threats. Journal of clinical medicine 2018 Nov 8;7(11). PMID:30413016

42. Krishnan S, Mandala MA, Wolf SL, Howard A, Kesar TM. Perceptions of stroke survivors regarding factors affecting adoption of technology and exergames for rehabilitation. PM&R Wiley Online Library; 2023;15(11):1403–1410.

43. Garcia Reyes EP, Kelly R, Buchanan G, Waycott J. Understanding Older Adults' Experiences With Technologies for Health Self-management: Interview Study. JMIR aging 2023 Mar 21;6:e43197. PMID:36943333

44. Yusif S, Soar J, Hafeez-Baig A. Older people, assistive technologies, and the barriers to adoption: A systematic review. International journal of medical informatics 2016 Oct;94:112–6. PMID:27573318

45. Centers for Disease Control and Prevention. Telehealth interventions to improve chronic disease. URL https://www cdc gov/dhdsp/pubs/teleh ealth htm 2022;

46. Tanaka K, Parker JR, Baradoy G, Sheehan D, Holash JR, Katz L. A comparison of exergaming interfaces for use in rehabilitation programs and research. Loading. 2012;6(9).

47. Oda N, Kim J-H, Yamamoto Y. Information Presentation Methods for Setting Achievable and Meaningful Goals on Fitness Apps. Proceedings of the 2022 ACM Conference on Information Technology for Social Good 2022. p. 61–67.

48. Muñoz JE, Cao S, Boger J. Kinematically adaptive exergames: personalizing exercise therapy through closed-loop systems. 2019 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR) IEEE; 2019. p. 118–1187.

49. Abedi A, Colella TJF, Pakosh M, Khan SS. Artificial intelligence-driven virtual rehabilitation for people living in the community: A scoping review. npj Digital Medicine 2024 Feb 3;7(1):25. doi: 10.1038/s41746-024-00998-w

50. Delbaere K, Valenzuela T, Lord SR, Clemson L, Zijlstra GAR, Close JCT, Lung T, Woodbury A, Chow J, McInerney G, Miles L, Toson B, Briggs N, van Schooten KS. E-health StandingTall balance exercise for fall prevention in older people: results of a two year randomised controlled trial. BMJ (Clinical research ed) 2021 Apr 6;373:n740. PMID:33824131

51. Fischl C, Blusi M, Lindgren H, Nilsson I. Tailoring to support digital technology-mediated occupational engagement for older adults - a multiple case study. Scandinavian journal of occupational therapy 2020 Nov;27(8):577–590. PMID:32396419

52. Collado-Mateo D, Lavín-Pérez AM, Peñacoba C, Del Coso J, Leyton-Román M, Luque-Casado A, Gasque P, Fernández-del-Olmo MÁ, Amado-Alonso D. Key Factors Associated with Adherence to Physical Exercise in Patients with Chronic Diseases and Older Adults: An Umbrella Review. International Journal of Environmental Research and Public Health 2021 Feb 19;18(4):2023. doi: 10.3390/ijerph18042023

53. Sanford S, Liu M, Nataraj R. Concurrent Continuous Versus Bandwidth Visual Feedback With Varying Body Representation for the 2-Legged Squat Exercise. Journal of sport rehabilitation

2021 Feb 16;30(5):794–803. PMID:33596545

54. Tuena C, Pedroli E, Trimarchi PD, Gallucci A, Chiappini M, Goulene K, Gaggioli A, Riva G, Lattanzio F, Giunco F, Stramba-Badiale M. Usability Issues of Clinical and Research Applications of Virtual Reality in Older People: A Systematic Review. Frontiers in human neuroscience 2020;14:93. PMID:32322194

55. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: Updated guidelines for reporting parallel group randomised trials. Journal of pharmacology & pharmacotherapeutics 2010 Jul;1(2):100–7. PMID:21350618

56. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, Altman DG, Barbour V, Macdonald H, Johnston M, Kadoorie SEL, Dixon-Woods M, McCulloch P, Wyatt JC, Phelan AWC, Michie S. Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. BMJ (Online) 2014;348(March):1–12. PMID:24609605

57. Butcher NJ, Monsour A, Mew EJ, Chan A-W, Moher D, Mayo-Wilson E, Terwee CB, Chee-A-Tow A, Baba A, Gavin F, Grimshaw JM, Kelly LE, Saeed L, Thabane L, Askie L, Smith M, Farid-Kapadia M, Williamson PR, Szatmari P, Tugwell P, Golub RM, Monga S, Vohra S, Marlin S, Ungar WJ, Offringa M. Guidelines for Reporting Outcomes in Trial Protocols. JAMA 2022 Dec 20;328(23):2345. doi: 10.1001/jama.2022.21243

58. Iancu I, Iancu B. Designing mobile technology for elderly. A theoretical overview. Technological Forecasting and Social Change Elsevier; 2020;155:119977.

59. LaMonica HM, Davenport TA, Roberts AE, Hickie IB. Understanding technology preferences and requirements for health information technologies designed to improve and maintain the mental health and well-being of older adults: participatory design study. JMIR aging JMIR Publications Inc., Toronto, Canada; 2021;4(1):e21461.

60. Borghese NA, Murray D, Paraschiv-Ionescu A, de Bruin ED, Bulgheroni M, Steblin A, Luft A, Parra C. Rehabilitation at Home: A Comprehensive Technological Approach. 2014. p. 289–319. doi: 10.1007/978-3-642-54816-1_16

61. Ringgenberg N, Mildner S, Hapig M, Hermann S, Kruszewski K, Martin-Niedecken AL, Rogers K, Schättin A, Behrendt F, Böckler S, Schmidlin S, Jurt R, Niedecken S, Brenneis C, Bonati LH, Schuster-Amft C, Seebacher B. ExerG: adapting an exergame training solution to the needs of older adults using focus group and expert interviews. Journal of neuroengineering and rehabilitation 2022 Aug 16;19(1):89. PMID:35974409

62. Peters MDJ, Marnie C, Colquhoun H, Garritty CM, Hempel S, Horsley T, Langlois E V, Lillie E, O'Brien KK, Tunçalp Özge, Wilson MG, Zarin W, Tricco AC. Scoping reviews: reinforcing and

advancing the methodology and application. Systematic reviews 2021 Oct 8;10(1):263. PMID:34625095

63. Valenzuela T, Razee H, Schoene D, Lord SR, Delbaere K. An interactive home-based cognitive-motor step training program to reduce fall risk in older adults: qualitative descriptive study of older adults' experiences and requirements. JMIR Aging 2018 Nov 30;1(2):e11975. doi: 10.2196/11975

64. Hong J, Kim SW, Joo H, Kong HJ. Effects of smartphone mirroring-based telepresence exercise on body composition and physical function in obese older women. Aging Clinical and Experimental Research Springer Science and Business Media Deutschland GmbH; 2022 May 1;34(5):1113–1121. PMID:35028918

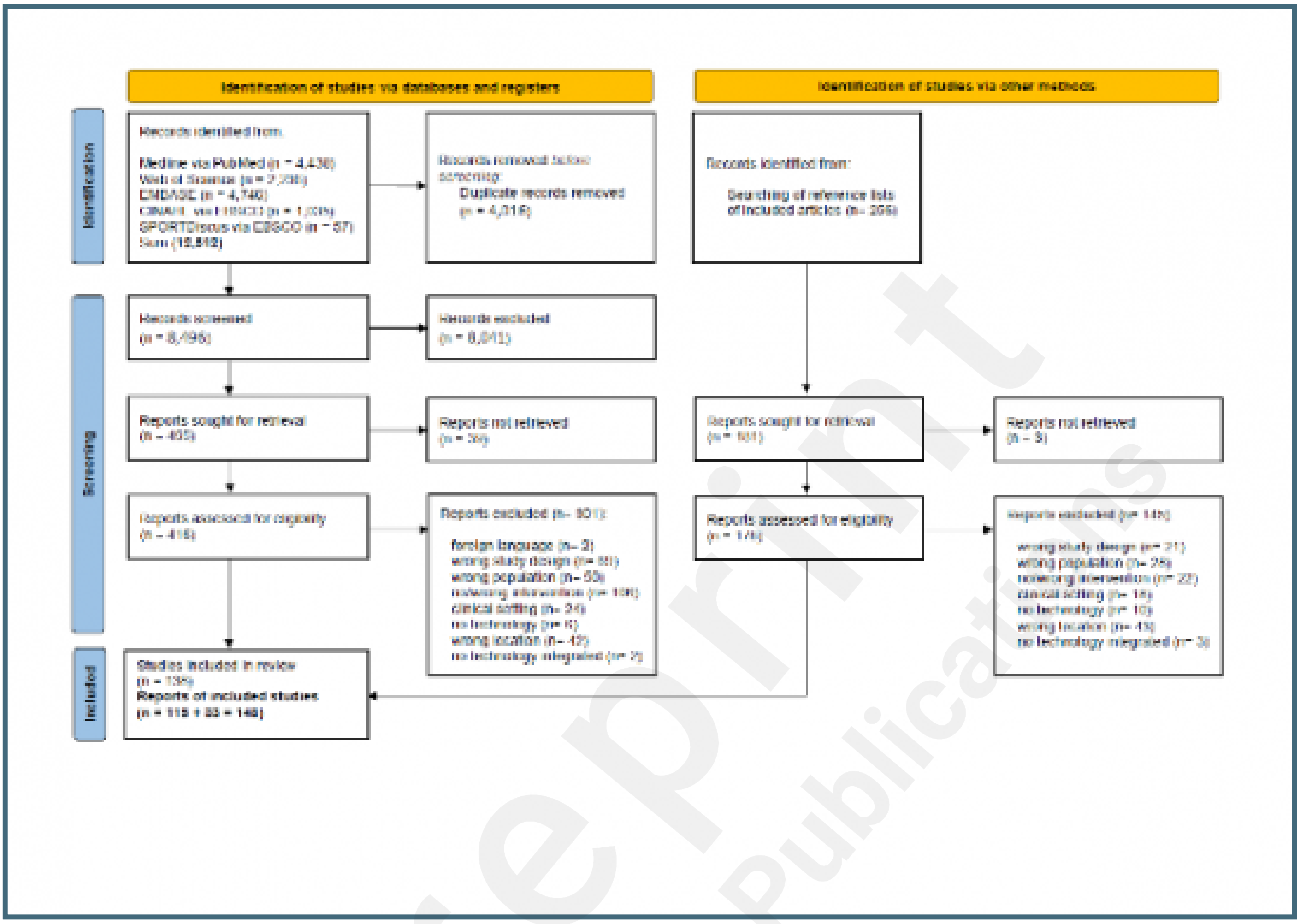
65. Park J, Heilman KJ, Sullivan M, Surage J, Levine H, Hung L, Ortega M, Kirk Wiese LA, Ahn H. Remotely supervised home-based online chair yoga intervention for older adults with dementia: Feasibility study. Complementary Therapies in Clinical Practice 2022 Aug;48:101617. doi: 10.1016/j.ctcp.2022.101617

66. Pollock D, Davies EL, Peters MDJ, Tricco AC, Alexander L, McInerney P, Godfrey CM, Khalil H, Munn Z. Undertaking a scoping review: A practical guide for nursing and midwifery students, clinicians, researchers, and academics. Journal of advanced nursing 2021 Apr;77(4):2102–2113. PMID:33543511

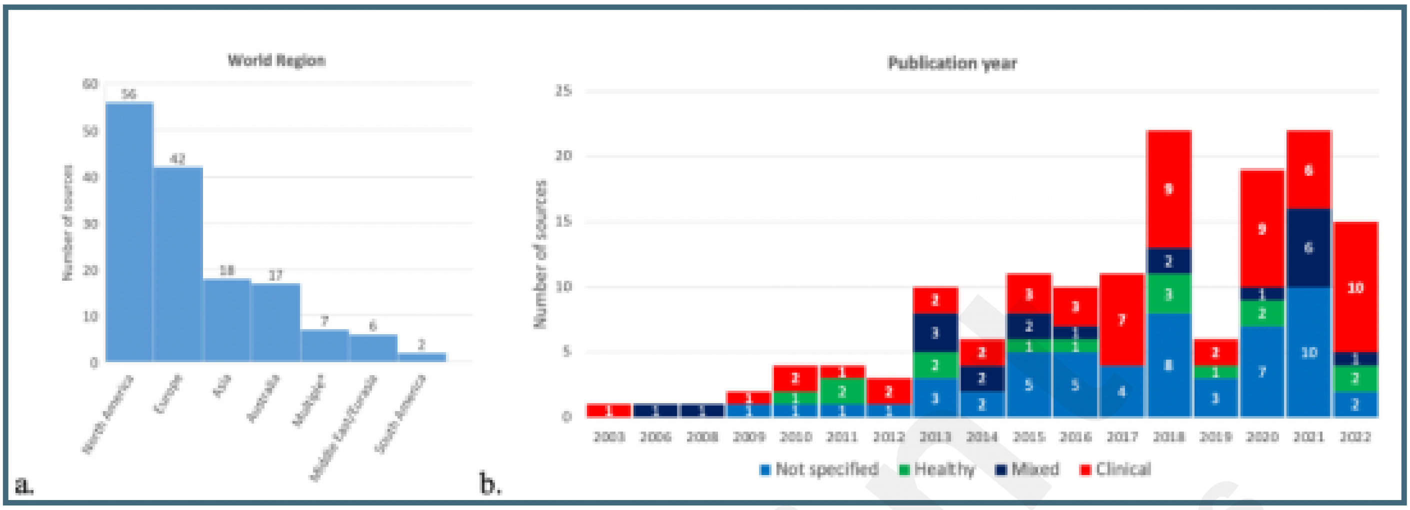
Supplementary Files

Figures

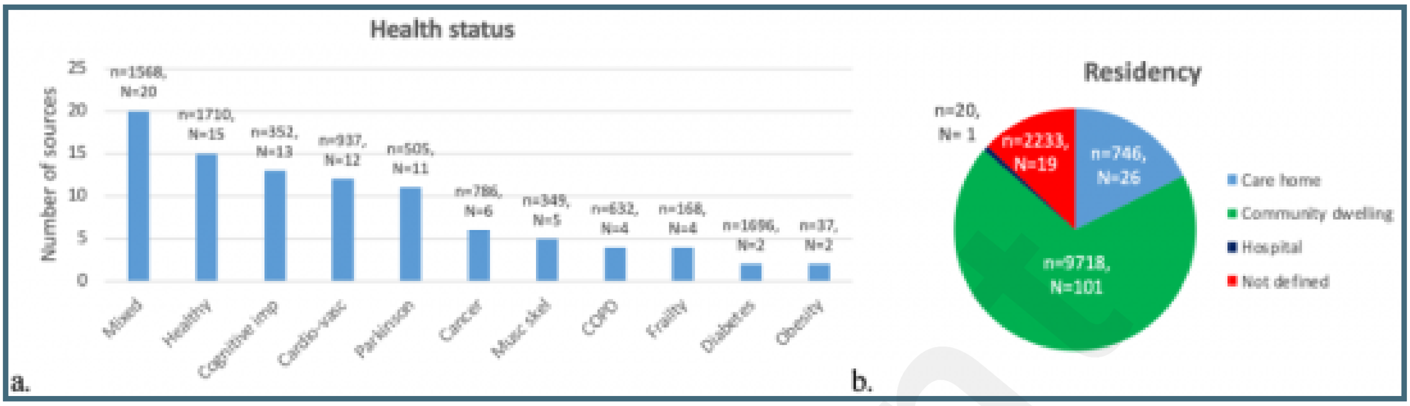
Flowchart search process.



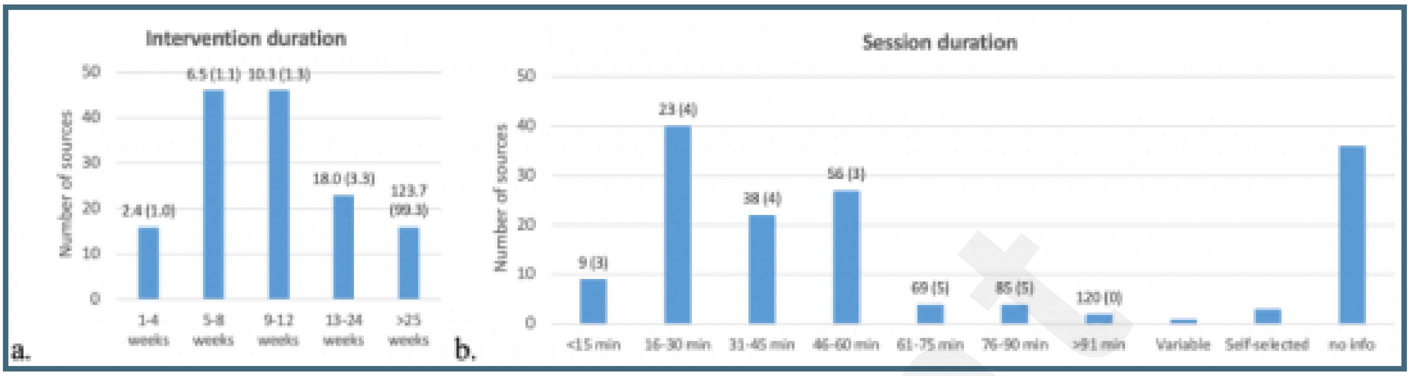
a. Number of included sources by world region. b. and by publication year and health status.



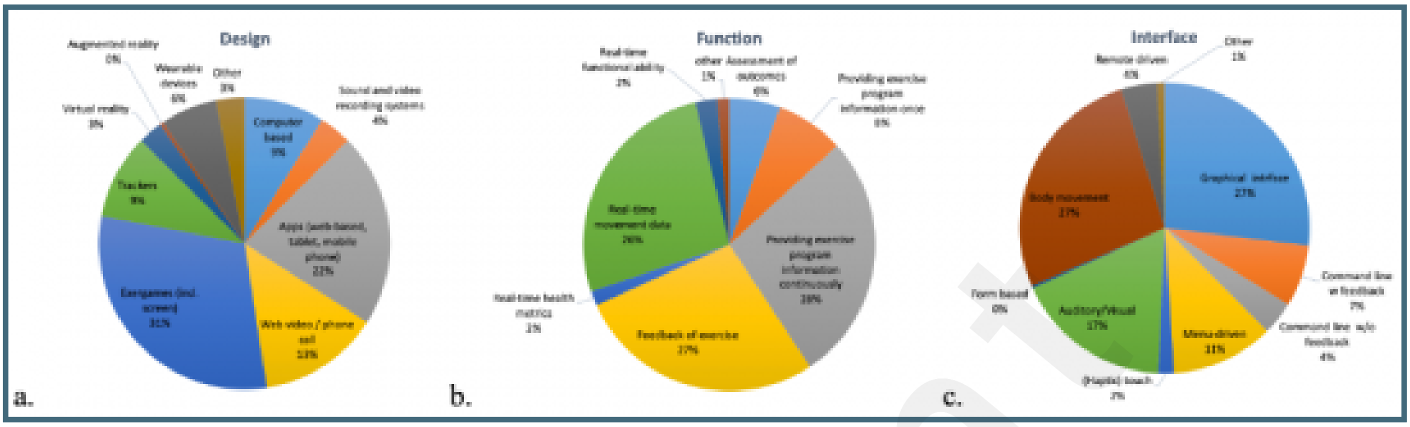
Number of included sources (N) by reported a. health status and b. residency. With n being the total number of participants with cardio-vascular disease (Cardio-vasc); cognitive impairments (Cognitive imp); chronic obstructive pulmonary disease (COPD) and musculoskeletal disease (Musc skel).



Number of sources stratified by a. intervention duration (average and SD) and b. session duration (average and SD). For intervention duration in minutes (min), the average duration and corresponding standard deviation per group is also presented.



Extracted parameter count (in % of sources) for a. technology design, b. function and c. interface categories.



Multimedia Appendixes

Search string development.
URL: http://asset.jmir.pub/assets/f7c30d9ae511049fc2b9d865ccd19365.docx

Data extraction topics.
URL: http://asset.jmir.pub/assets/9568eebad31b749e3c8f581034fa65cd.docx

Coding framework for data extraction.
URL: http://asset.jmir.pub/assets/9199748e4a5e6daf1b40a05bccdfae28.docx

Result tables and sources.
URL: http://asset.jmir.pub/assets/9f6aa0d1c98f02c4ae0710fc6ec25813.docx

Supplementary Material: Full data extraction.
URL: http://asset.jmir.pub/assets/98e1aaff64e40340e6bb734882fb5cf9.xlsx

Supplementary material: Excluded sources reasons.
URL: http://asset.jmir.pub/assets/46e2615f70ec5f9f77d167c658e1a1ab.xlsx