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Review Article

Current Trends in Virtual Exercise Interventions Among People With Disabilities: A Scoping Review

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KEYWORDS
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People with disability;
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Abstract *Objective:* To analyze existing literature on virtual exercise interventions delivered to people with disabilities to assess effectiveness, efficiency, usability, satisfaction, and feasibility, and describe current trends that aimed to improve health outcomes among people with disabilities.
Data Sources: CINAHL, MEDLINE, and PsycINFO were searched.
Study Selection: Articles were included if they were (1) incorporated a virtual exercise intervention including people with physical disabilities and mobility limitations aged 18 years and older and (2) published between the years of 2009-August 14, 2024 with free access to full-text, peer-reviewed papers; and (3) published in English. Exclusion criteria: (1) unrelated to disability;

List of abbreviations: CINAHL, cumulative index of nursing and allied health literature; IMI, intrinsic motivational instrument; MS, multiple sclerosis; PD, Parkinson's disease; PRISMA, preferred items for systematic reviews and meta-analyses; PWD, people with disabilities; VR, virtual reality.

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(2) non—peer-reviewed articles; (3) protocol or review papers; (4) study focused on virtual exercise through perspective other than that of the participant; (5) study's primary objectives were not related to physical functioning and/or rehabilitation; and (6) study used only qualitative methods.

Data Extraction: A single search was conducted from January 2023 and ceased on August 14, 2023. Duplicate records were pulled from the article search within each database; article abstracts were assessed; and finally, full-text articles were retained upon meeting inclusion criteria. The primary researcher conducted the initial search, while 2 independent reviewers, J.R. and J.W., assisted with and confirmed article extraction.

Data Synthesis: Thirty-seven articles were included. Trends were explained by recapitulating statistically significant results per study among each disability group and virtual exercise delivery mode, exercise type, and intervention synchronicity.

Conclusions: More facilitators, satisfaction, usability, and perceived benefits were reported when compared to reported barriers among people with physical disabilities and mobility limitations who participated in virtual exercise interventions.

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Exercise is a critical component of a healthy lifestyle for all individuals, including those living with physical disabilities and mobility limitations.[1-3] Participating in exercise has well-established health-related benefits for people with disabilities (PWD), including prevention,[1,2,4] management,[3,5,6] treatment of secondary and/or chronic health conditions,[3,7,8] healthy decision-making behaviors,[6,9] and promotion of a generally healthier lifestyle.[10-13] Previous literature has consistently shown that exercise for PWD alleviates bodily pain,[14-16] facilitates mental and emotional health,[6,9] and assists in regulating physiological systems.[11,17,18] Despite overwhelming evidence that proves the benefits of exercise, a statistically significant amount of U.S. population does not incorporate exercise into their lifestyle or daily regimen. Additionally, the rates of physical inactivity are disproportionately higher among PWD.[1-3,10,11,14,19]

Traditionally, when engaging in community exercise programs, people needed to be onsite at a fitness center, recreational facility, or clinic.[19-22] However, this can be challenging for PWD as it produces barriers to engagement such as transportation, safety, and accessibility of personal and structural environments.[13,19-24] To address this, health professionals and researchers have begun developing strategies to make exercise convenient for PWD by bringing exercise into the home, opposing the stigma that exercise is only available at a community facility.[19,25,26] Furthermore, in response to the COVID-19 pandemic, online exercise interventions have emerged quickly as a resolution for restricted access to fitness and health care facilities.[19,25] Remote delivery of exercise interventions and programs circumnavigates the many barriers of the built environment encountered by PWD, such as inaccessible spaces, safety of indoor and outdoor exercise opportunities, and cost of participation.[21,23,24] However, with the recent explosion of advancements in accessibility and inclusivity, such as telehealth and mobile health technology, there is an array of models in exercise programs that can be delivered virtually to enhance the physical and mental health of PWD.[9,13,18,25,27] This growing area of online and telecommunication technology in research and rehabilitation medicine requires a comprehensive understanding of current and commonly reported barriers and facilitators of exercise among PWD. Specifically, exploration of perceptions and preferences of online participation and engagement in exercise programs are needed to develop and refine tailored interventions in the virtual environment.

Prior to the COVID-19 pandemic, comprehensive scoping reviews identified several types of virtual exercise interventions, including telehealth (eg, videoconferencing), mobile health (eg, app-based), digital health (eg, wearable devices), and online or virtual interaction (eg, websites with video content or virtual reality [VR] gaming).[13] Given the intensity of telehealth and exercise after the COVID-19 pandemic, there is a need to understand current approaches for virtual health and wellness opportunities for PWD.[9,19,25] Therefore, the aim of this scoping review was to aggregate and describe current trends in virtual exercise that aimed to improve health outcomes among adults with disabilities by investigating effectiveness, efficiency, usability, satisfaction, and feasibility. Additional topics of interest included strategies for delivering virtual exercise interventions, the level of supervision of the exercise training, the exercise dose and duration, targeted health outcomes, and participant preferences. The purpose of this review was to collect saturated results to establish a future research agenda investigating successful participation, adherence, and implementation of PWD who participate in an online health intervention or program. The consequences of not performing this scoping review include a growing body of evidence to be left unexplored with such specific and defined parameters, as well as a premature initiative to create future interventions without a strong understanding of strategies to create a successful delivery for PWD and mobility limitations.

Methods

Article selection

Articles were chosen from 3 databases: CINAHL, MEDLINE, and PsycINFO. Article selection was initiated in January 2023 and ceased on August 14, 2024, and no further studies were conducted. The exact search strings for each database can be found in Supplemental Appendix S1. This scoping review was guided using JBI methodology and adheres to the preferred items for systematic reviews and meta-analyses for scoping review guidelines and informs on all required criteria appropriately.[28,29]

Inclusion and exclusion criteria

Articles were included if they were (1) incorporated a virtual exercise intervention including people with physical disabilities and mobility limitations aged 18 years and older; (2) published between the years 2009 and August 14, 2024, with free access to full text, peer-reviewed papers; and (3) published in English. Articles were excluded as follows (1) unrelated to disability; (2) non−peer-reviewed articles (eg, dissertations, conference posters, professional learning); (3) protocol or review papers; (4) the study focused on virtual exercise through perspective other than that of the participant (eg, caregiver, health professional, support network); (5) the study's primary objectives were not related to physical functioning and/or rehabilitation (eg, cognitive, nutritional); and (6) the study used qualitative methods.

Article extraction and analysis

For article extraction, a single search was conducted and occurred in 3 segments. First, a study of CINAHL, MEDLINE, and PsycINFO databases was executed using a search query, which was created by the primary researcher and validated by a university librarian. Duplicate records were pulled from the article search within each database. Second, after the initial search, article abstracts were analyzed and either retained or excluded depending on meeting or failing to meet inclusion criteria. Third, full-text articles were reviewed and either retained or excluded depending on meeting or failing to meet inclusion criteria. Two independent reviewers, J.R. and J.W., were involved in article extraction, and discrepancies were resolved between them. Content classification within each article consisted of physical disabilities, type of virtual exercise delivery mode, intervention synchronicity, health outcomes, and intervention assessment type.

Physical disabilities

Physical disability was defined as difficulty or inability to move body part(s) caused by diseases, degeneration, or disorder of the nervous system.[6,7,17]

Virtual exercise intervention deliveries and synchronicity

After completing the scoping review, virtual deliveries were categorized by 7 intervention types (1) Nintendo Wii; (2) Xbox 360±Kinect; (3) PlayStation II±EyeToy; (4) home-based (with an app or delivered exercise kit); (5) videoconferencing; (6) privately developed software; and (7) wearable devices. The level of supervision during exercise training (also known as intervention synchronicity) was collected and categorized as synchronous, asynchronous, or performed in a clinical setting.

Intervention assessment types

Synchronous interventions were defined as training methods where participants exercised with a trainer, researcher, or therapist using real-time online videoconferencing platforms to provide instructions or feedback and collect live data.[25] Asynchronous interventions were defined as interventions where participants exercised independently on their own schedule with their choice of environment and received feedback from a trainer, researcher, or therapist using different modes of delivery (eg, videoconferencing, online portal communication).[25] Examples of asynchronous communication included videos uploaded to a smart device web-based application, emails, and telephone calls. Interventions performed in a clinical setting, for the parameters of this review, allowed participants to participate in a virtual exercise intervention in the physical presence of a therapist or researcher for protocol requirements such as safety concerns or the simultaneous collection of other clinical data, such as blood measures, clinical imaging, or other in-person testing measurements (timed-up and go, 6-min walk test, Wolf motor functioning, etc). Intervention synchronicity is further elaborated on by the type of intervention and intervention assessment types in the results section. Intervention assessment types were classified as (1) effectiveness; (2) efficiency; (3) feasibility; (4) satisfaction; and (5) usability. Effectiveness was defined as the degree to which the intervention was successful in producing a desired result. Efficiency was defined as the ability to accomplish something with the least amount of wasted time, money, and effort or competency in performance. Feasibility was defined as the state or degree of being reasonable or conveniently done or achieved. Satisfaction was defined as fulfillment of one's wishes, expectations, or needs. Usability was defined as a quality attribute that assessed how easy user interfaces were to use.

Health outcomes

Health outcomes of each study were collected and separated by (1) functional independence; (2) cardiorespiratory; and (3) psychosocial variables. Functional independence outcomes included balance, mobility, strength, endurance, reach, walking ability/gait, limb function, motor/sensory impairment, and dexterity. Cardiorespiratory outcomes included oxygen consumption, heart rate, aerobic capacity, energy expenditure, and physical activity. Psychosocial outcomes included quality of life, satisfaction, and depression.

Pertaining to the relevance of the primary objective for the scoping review, only statistically significant results were reported for the intervention groups. Statistical significance was defined as an α value of 0.05 found after intervention, between or within samples. Effect sizes or generalizations were not coded. Specific information regarding comprehensive results may be found in the respective referenced study.

Data analysis

Descriptive statistics were employed to interpret and summarize a total of 37 studies. For each study, disability type, dose and duration, intervention synchronicity, health outcomes, intervention assessment type, results, and subjective participant experiences (when applicable) were collected. It is

Table 1 Descriptive matrix of included articles, virtual exercise delivery strategies, and participant demographics

Disability	Studies (n, %)	Participants (n, m/f)	Mean Age (y)	Mean Chronicity (y)
Stroke	14 (38)	300 (119/84)	56.56	2.86
Spinal cord injury	10 (27)	167 (109/28)	44.75	13.44
Multiple sclerosis	5 (14)	329 (109/220)	45.43	11.46
Traumatic brain injury	6 (16)	158 (96/46)	44.62	4.08
Parkinson disease	3 (1)	24 (10/13)	66.25	10.70
Other	3 (1)	52 (32/11)	36.73	13.30
Virtual health delivery				
Nintendo Wii	10 (27)	298 (107/121)		
Xbox 360±Kinect	8 (22)	242 (148/98)		
PlayStation II±EyeToy	3 (1)	63 (52/11)		
Home-based app or exercise kit	6 (16)	218 (67/106)		
Videoconferencing	6 (16)	83 (19/40)		
Privately developed software	5 (14)	102 (73/31)		
Wearable devices	2 (1)	23 (19/5)		
Synchronicity				
Synchronous	6 (16)	122 (37/65)		
Asynchronous	8 (22)	309 (153/156)		
Clinical setting	23 (62)	579 (333/202)		
Health outcome				
Functional independence	24 (65)			
Cardiorespiratory	11 (30)			
Psychometrics	12 (32)			
Intervention assessment				
Effectiveness	30 (81)			
Efficiency	4 (11)			
Feasibility	18 (59)			
Satisfaction	6 (16)			
Usability	6 (16)			

important to note that several studies overlapped across one or more dependent variables, which is described in the results section.

Data were presented from 2 perspectives. First, the intervention assessment type was described by individual studies, their respective sample, and dose and duration (table 1). Second, intervention trends were described by disability group, exercise type, intervention synchronicity, and statistically significant outcome measures per virtual exercise delivery system (table 2).[30-64]

Results

Three segments of article selection resulted in a total of 37 articles that met all inclusion criteria. The process of article selection is shown in figure 1, a diagram of the preferred items for systematic review and meta-analyses. To provide an in-depth understanding of each study's sample, sex, mean age, and mean chronicity characteristics were collected (when provided by the authors) and included in table 1. Missing data were omitted from this scoping review's dataset, thus numbers presented are a direct summation or average of what was available in the included articles. This strategy was verified by a university statistician. No efforts were made to locate missing data. Results of effectiveness, efficiency, feasibility, satisfaction, and usability which were analyzed in each included study can be found in Supplemental Appendix S1.

The included studies were from Australia,[33,57] Brazil,[38,46] Canada,[54] China,[55] Germany,[48] India,[49] Israel,[59] Italy,[30-32,65] Korea,[34,62] Malaysia,[41,43,60] Mexico,[63] Netherlands,[29,61] Pakistan,[52] Spain,[36,40,42] Turkey,[44,45] and the USA[19,35,37,47,50,52,53,56,58,64] representing high-income,[19,30-40,42,46,48,53-59,61,62,64,65] upper-middle,[38,44-46,50,63] middle,[41,43,49,55,60] and lower-middle countries.[52]

Disability

A total of 6 disability groups were identified: stroke, SCI, multiple sclerosis (MS), TBI, Parkinson's disease (PD), and other (spinocerebellar ataxia, physical disabilities not specifically mentioned, and one study included autoimmune disease, chronic obstructive pulmonary disease, diabetes mellitus with/without chronic lower back pain, and Guillain-Barre syndrome). A total number of 1030 people with the aforementioned disabilities, with a mean age of 49.05 years, were included in the review. Within each disability category, the number of people who participated in virtual exercise interventions was also included and can be found in table 1.

Table 2 Virtual exercise delivery with included populations, exercise type, synchronicity, and statistically significant results

Virtual Exercise Intervention	Population Sample	Exercise Type	Intervention Synchronicity	Significant Outcome Measures
Nintendo Wii	MS[30,31] SCI[32] Stroke[34,35,39] TBI[33,36] Other[35,38]	Balance[30-35] Mobility[30,31,35,37] Aerobic[30-34,39] Strength[30,31,37]	Synchronous Asynchronous Clinical setting[30-39]	Functional independence[30,34-38] Cardiorespiratory[32,37,39] Psychometrics[35,37,38]
Xbox 360±Kinect	MS[40] Stroke[41,42,44-47] TBI[43,48] Stroke[41,42,44-47]	Balance[40-45] Mobility[43,46,47] Aerobic[42,46] Gait[40-42,44,45] Strength[42]	Synchronous[40] Asynchronous[48] Clinical setting[41-47]	Functional independence[40-47] Cardiorespiratory Psychometrics
Playstation II±EyeToy	SCI[35,49] Stroke[37]	Balance[49] Mobility[37] Aerobic[35] Strength[35,37]	Synchronous Asynchronous Clinical setting[35,37,49]	Functional independence[37,49] Cardiorespiratory Psychometrics[37]
Home-based (w/app and/or exercise kit)	MS[48] SCI[19,50,51] Stroke[50,52] TBI[50,54] PD[50]	Balance[50] Mobility[19,52] Aerobic[19,48,51,53] Strength[19,30,48,50]	Synchronous[51,52] Asynchronous[19,48,50,52,53] Clinical setting	Functional independence[52] Cardiorespiratory[51] Psychometrics
Videoconferencing	SCI[51,54] Stroke[57,58] PD[55,56]	Balance[55] Mobility[55-57] Aerobic[51,54,58] Strength[54]	Synchronous[51,54-57] Asynchronous[58] Clinical setting	Functional independence[55,58] Cardiorespiratory[57] Psychometrics[51,54,56,58]
Privately developed software	MS[59] SCI[61,62] Stroke[60,63]	Balance[59-61] Mobility[60,62,63] Strength[60,63] Gait[61]	Synchronous Asynchronous Clinical setting[59-63]	Functional independence[59,60,62,63] Cardiorespiratory Psychometrics[60]
Wearable devices	SCI[51,64]	Aerobic[51,64] Strength[64]	Synchronous[51] Asynchronous[64] Clinical setting	Functional independence Cardiorespiratory[64] Psychometrics[51,64]

About 38% of studies focused on stroke, 27% on SCI, 14% on MS, 16% on TBI, 1% on PD, and 1% on other disabilities. It is important to note that an overlap in this disability category comes from Singh et al[43] and Van de Winckel et al[50] who both included groups of physical disabilities that were either not specifically mentioned or more than one disability group in their samples (eg, stroke and SCI and TBI and PD), listed under the "Other" category in table 1.

Virtual exercise intervention

A total of 7 virtual exercise intervention delivery modes were analyzed (1) Nintendo Wii; (2) Xbox 360±Kinect; (3) PlayStation II±EyeToy; (4) home-based app and/or exercise kit; (5) videoconferencing; (6) privately developed software; and (7) wearable devices.

Nintendo Wii comprised the the majority of virtual exercise delivery at 27% of studies. A total of 298 participants with MS (n=126, 42%), SCI (n=10, 3%), stroke (n=81, 27%), TBI (n=38, 13%), and other types of disability (n=43, 14%) were studied within this intervention. Equipment included a Wii console with VR game programming, a pair of nun chucks, a balance board, and a monitor to display games. Examples of games using the Wii nun chucks included tennis, bowling, and boxing. Examples of using the Wii balance board included soccer, table tilt, and balloon breaker. Primary focuses of the exercise using Nintendo Wii were balance, mobility, aerobics, and strength. One hundred percent of Nintendo Wii interventions were performed in clinical settings. Subjective participant data collection was identified in 5 studies and yielded experience feedback, barriers, and intervention preferences.[33,35-37,64] Experience feedback demonstrated participants reporting having fun during the intervention,[57] feeling better at performing the game,[38] and appearing motivated.[38,43] Barriers identified by participants were related to the physical functioning of performance of virtual gaming, specifically chronic pain and weight shifting, and stepping on and off the balance board to play boxing games.[59,34] According to participant preference, participants perceived themselves to be in control of game selection and enjoyed this feeling.[34]

Xbox 360±Kinect was used in 22% of studies. Two hundred thirty participants with MS (n=47, 20%), stroke (n=123, 54%), and TBI (n=84, 3%) participated in this virtual exercise intervention. A gaming console with VR game programming, a

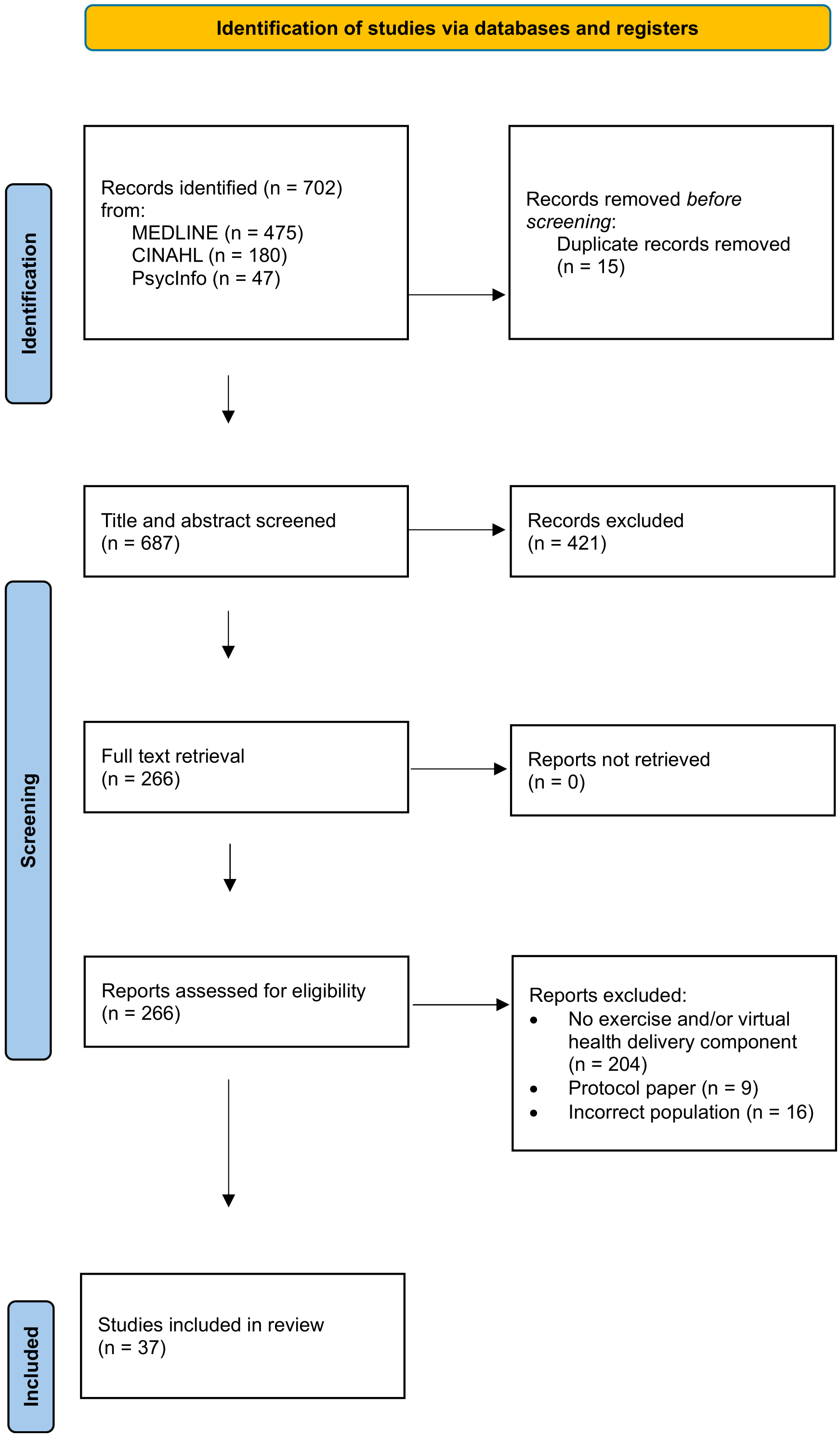

Fig 1 PRISMA flow diagram of the article selection process.

sensor with a built-in camera, and a handheld gaming remote comprised the equipment package. Kinect sports, golf, table tennis, and mouse mayhem were examples of the equipment package. Balance, mobility, aerobics, and gait training exercises were investigated using Xbox 360±Kinect virtual exercise intervention synchronously, asynchronously, and in clinical settings. Two studies collected subjective data from participants. Aramaki et al[46] illustrated participant's experiences and perceived benefits. Participants in this study reported that VR gaming assisted in enhancing both occupational and social performance and participation. Türkbey et al[44] demonstrated participant satisfaction with 100% of participants reporting that training was enjoyable and aided in their recovery process.

Eighteen percent of studies used a home-based intervention with a teleexercise application with or without an exercise kit. Two hundred and eighteen participants with MS (n=126, 58%), SCI (n=22, 10%), stroke (n=14, 6%), TBI (n=29, 13%), and PD (n=1, <1%) participated synchronously and/or asynchronously. Eighty-four percent of studies collected subjective data from participants, noting experience, perceived benefits, difficulties, barriers, and facilitators. One randomized control trial found participants to have statistically significantly less confidence postintervention using exercise equipment and accessing help.[53] Conversely, a usability study found that 90% of participants rated the program as good or excellent, and 85% were satisfied with their experience within the intervention.[56] Another feasibility study found that participants in rural areas expressed difficulty with technology and internet connectivity; however, participants generally reported that teleexercise was a favorable method of exercise, noting specifically the accessibility and feasibility of participating at home with the accountability of a specialist trainer.[41] Another study found reciprocal relationships between exercise levels of difficulty and enjoyment, meaning the more enjoyment participants experienced, the more they challenged themselves within the game, which led to increased difficulty in performing tasks.[37] Another study reported close to half of their participant sample (43%) had difficulty connecting to the intervention when their internet connection was unreliable.[51]

Sixteen percent of studies used videoconferencing to study balance, mobility, aerobics, and strength exercises both synchronously and asynchronously among participants with SCI (n=8, 9%), stroke (n=52, 63%), and PD (n=23, 28%). Eighty-three percent of studies that used videoconferencing collected subjective participant data. A study collected postintervention data on user experience using a 5-point Likert scale and questions related to their telerehabilitation experience and system component usability. The participants reported strong positive experiences on a favorable experience (score of 4.4) and suggested the same treatment to someone with a similar condition (score of 4.8).[57] An acceptability study among people with PD found both barriers and facilitators of their intervention. According to participants, barriers related to the instabilities in their health status, issues understanding the technology, and personal frustration with their abilities to perform exercises all affected their time within the intervention. Conversely, facilitators related to participant relationships to health coach administering sessions, participants' perceived benefits on the intervention's affect their health and well-being, and psychosocial variables such as motivation and familial/caregiver support led to their satisfaction and usability to complete the intervention.[32] A case series delivered to people with SCI found participants expressed difficulty with technology and internet connectivity in rural areas.[41] Another study found participant barriers related to environmental concerns and preconceived notions about exercising.[41] Facilitators in the same study related to minimal equipment needed and barrier removal for participating.[41] Finally, this feasibility study exhibited the perceived benefits of participants, noting specifically their personal involvement with the online physical activity group and high satisfaction with the intervention on their health.[31]

Fourteen percent of studies used privately developed software to deliver virtual exercise interventions to participants with MS (n=30, 25%), SCI (n=45, 38%), and stroke (n=45, 38%). Because these interventions were delivered with specific software and equipment necessary to deliver the exercise programs, all studies were hosted in a clinical setting. Fifty percent of studies collected subjective participant feedback and found perceived benefits such as enhanced upper limb rehabilitation when using VR.[36] Furthermore, perceived difficulty was only mentioned once and was directed at a computer's technical errors, not participants' ability to use technology.[63]

Eight percent of studies used PlayStation II±EyeToy among participants with SCI (n=47, 75%) and stroke (n=16, 25%) in clinical settings addressing balance, mobility, aerobics, and strength exercise types. Motivation was the only statistically significant psychosocial variable reported.[38] Only one study collected feedback from participants using an intrinsic motivation instrument. When participants were asked about performing physical activity using VR gaming, they reported a 6.7 out of 7 score, where a higher number signified a better score.[43]

Finally, 5% of studies used wearable devices for virtual exercise delivery. Participants with SCI (n=23, 100%) participated in aerobic and strength exercises both synchronously and asynchronously. Only one study collected subjective responses and found both perceived barriers and facilitators from their samples.[59] Regarding difficulties of participating in virtual exercise interventions using wearable devices, participants reported levels of pain, employment status, hospitalizations, weather, and lack of resources as reasons for a decrease in exercise participation during the intervention. Alternatively, in the same study, when participants received motivation notifications on their wearable devices, this led to feelings of motivation and encouragement.

Overlap of virtual exercise intervention delivery options occurred among studies offering more than one virtual exercise delivery mode option at a time within their interventions.[33,41,43]

Intervention synchronicity

Synchronicity across all studies concluded that 62% of studies were conducted in a clinical setting, 22% of studies were conducted asynchronously, and 16% of studies were conducted synchronously. Overlap existed within this category, too, as Lee et al[34] provided both synchronous and asynchronous options within their intervention. Supplemental Appendix S2 illustrates a comprehensive view of each study's intervention assessment; whether or not it was successfully demonstrated according to the study authors' guidelines as well as the dose, duration, and exercise type for each study's intervention group.

Nintendo Wii

One hundred percent of studies using Nintendo Wii for virtual exercise intervention delivery examined effectiveness, and 30% of studies examined feasibility. All but 2 studies found virtual exercise interventions to be feasible and equally or more effective at improving health outcomes among individuals with MS, SCI, stroke, TBI, and other physical disabilities.[34,64]

Xbox 360±Kinect

Eighty-seven percent of studies were found to be effective, 100% of studies that assessed feasibility were found to be feasible, and 100% of studies that assessed efficiency met guidelines successfully.

Home-based (with app and/or exercise kit)

Sixty-seven percent of studies assessed effectiveness, and all but one study met authors' guidelines of intervention effectiveness. Eighty-three percent of studies assessed feasibility, and all but one study met authors' guidelines of feasibility. Thirty-three percent of studies assessed and successfully met author guidelines for satisfaction and feasibility.

Videoconferencing

Eighty-three percent assessed effectiveness, 83% assessed feasibility, 33% assessed satisfaction, and 50% assessed usability. All intervention assessments were successfully met by author-specific guidelines for intervention acceptance except English et al[57] which failed to meet effectiveness guidelines.

Privately developed software

Eighty percent of studies met effectiveness measures, 2 studies met feasibility guidelines, and one study assessed usability also meeting guidelines.

PlayStation II±EyeToy

All studies assessed effectiveness and were successful at meeting author-specific guidelines. Thirty-three percent analyzed feasibility and 33% analyzed satisfaction, and both feasibility and satisfaction were confirmed successfully.

Wearable devices

Each study analyzed effectiveness to be successful in delivery. Satisfaction was assessed in 50% of studies and found to meet guidelines; feasibility and usability were assessed in 50% of studies and were also found to be confirmed successfully.

Discussion

The primary goal of this paper was to describe trends in effectiveness, efficiency, usability, satisfaction, and feasibility of virtual exercise interventions being delivered to PWD. Within the included articles, virtual exercise interventions were explored among a sample of individuals primarily with stroke, SCI, MS, TBI, and PD. We identified a small (ie, compared to studies on people without disabilities) but an important number of published studies that used virtual exercise interventions in PWD. The major findings were studies used effective, feasible, satisfactory, and usable methods to successfully deliver virtual exercise interventions to people with physical disabilities and mobility limitations to improve upon their health outcomes postintervention. Respective percentages for successful delivery are as follows: 90% effectiveness, 93% feasible, 100% satisfactory, and 100% usable. Among the same theme of successful delivery, only 8 studies reported barriers or difficulties, and 21 studies reported facilitators, perceived benefits, or positive experiences. Examples of barriers to participation included decreased confidence in using exercise equipment,[19] chronic pain,[64] technological difficulties, and a lack of resources.[33,50,51,56,62,64] Examples of facilitators, perceived benefits, or positive experiences included participants recommending a program for others for treatment approach,[44,46,56,58,66] pain or symptom alleviation,[34,46,54,56,66] involvement with program personnel,[51,54,56,66] overall enjoyment with VR experience,[31,33,34,36,44,51,56,62,64] and accessibility.[44,51,55,56,62] The results of this scoping review lead to research gaps and future directions of forthcoming studies.

Future directions

A growing area of research surrounding virtual exercise and health-related interventions is the inclusion of holistic-based programs aimed at an individualized perspective of rehabilitation. Current literature describes the inclusion of health coaches, behavioral frameworks, and essences of an all-inclusive structure to emphasize simultaneous rehabilitation for the mind, body, and spirit.[6,10,22,67-69] Kritikos et al[69] highlighted the effect that emotions have on the physical performance of rehabilitation for PWD. In their study, a holistic rehabilitative framework was implemented to evoke either positive or negative emotions that resulted in the participant's level of physical performance and concluded that holistic integration into rehabilitation for PWD is imperative for reinforcing successful participation and engagement in the recovery process.[69]

Preferences of participants who have been successful in completing virtual exercise interventions should be prioritized and applied. Hypothetically, successful participation with high levels of engagement and adherence during interventions leads to the adoption of healthy lifestyle choices and decision-making behaviors.[22] If participants shared what made their time in an intervention successful, conceivably, future iterations of virtual exercise, and health-related interventions could have a higher likelihood of delivering effective, efficient, usable, satisfactory, and feasible interventions that produce more perceived facilitators and benefits of participating than perceived barriers or difficulties. This would be best achieved by specifically utilizing qualitative and/or mixed methodologies. For instance, a recent focus group study for PWD interested in sports was conducted to investigate user preferences for a smart device app to increase physical activity.[45] The results of the focus group concluded that user experience, social engagement, and gamification were the most important features of an app designed to track physical activity for PWD. These results were then used to inform the developmental process of creating the app. Along with the preference of participants, researchers should also examine the role of supportive networks, such as family, friends, caregivers, and medical team personnel, and the effect it makes on the success or failure of PWD in their virtual exercise or health-related interventions. Currently, literature related to supportive networks and virtual health interventions for PWD is related to the rise of the COVID-19 pandemic, and the applicability of these studies might not be translatable to the current perspectives of supportive networks to PWD as the pandemic has abated.[10,14,19,25,32,33,35] For example, a 2021 weighted secondary analysis found that approximately

43.3% of people with mobility disabilities used telehealth to actively seek medical care with decreased barriers or exposure to COVID-19 virus, such as public transportation or waiting in a doctor's office and eliminated the inclusion of their support network.[33] On the contrary, a mHealth study conducted during the rise of COVID-19 specifically for PWD found participants reported the use of telehealth as a lifestyle transformation; allowed them to engage in virtual nutrition, exercise, mindfulness, and health coaching classes accessibly; and allowed them to create a new social support network.[14] While both of these references targeted understanding PWD using telehealth during COVID-19, their focus was on 2 different areas.

Additionally, an apparent gap in the literature is the lack of studies conducted on adults with common types of disabilities such as cerebral palsy (CP). While CP was included in our search string, interventions for adults with CP who participate in virtual exercise interventions are scarce. Research supports exercise for adults with CP and has been shown to have effective, positive effects on their general health, specifically relief of pain and fatigue.[70-72] Future research should include adults with CP in virtual exercise interventions.

Finally, studies that include a broad array of representative disabilities (eg, developmental, learning), variant avenues of health and wellness (eg, self-care, mental health), enhanced VR accessible technology (eg, Oculus Quest, Valve Index, PlayStation VR, and HTC Vive Pro 2), and that used theoretical frameworks should be investigated. No studies in this scoping review incorporated any theoretical frameworks. Existing literature analyzes the use of Oculus Quest among youth and adolescents to improve socialization, mental health, and exercise adherence.[73,74] Using behavioral and theoretical frameworks to evaluate changes in decision-making processes, health behaviors, and sustained lifestyle choices provides researchers with insight into which specific aspects of their intervention contributed to these changes. According to Rimer et al (2012) and Glanz et al (2012), "using theory as a foundation for program planning and development is consistent with the current emphasis on using evidence-based interventions in public health, behavioral medicine, and medicine."[75]

Study limitations

This scoping review had limitations. First, gray literature was excluded based on no peer review, and even though all databases were thoroughly and comprehensively searched with an approved search query, a priori inclusion/exclusion criterion might have resulted in researcher bias in the approval of articles for the review and interpretation of articles. Second a priori definitions of the terms "physical disability" and "exercise" could have affected the choice to include or not include an article for review. This limitation affects the aim of the study by potentially limiting the literature we selected for review, which could have either augmented or altered our found results. Third, there is potential that statistically significant outcomes for each study were underreported, as results for this review were reported verbatim by individual study authors and could misrepresent case-by-case situations. There was also missing data that was not reported in this review because individual authors did not report it in their studies. Additionally, studies that targeted adolescents were not included. Finally, the use of technology was limited to virtual components that applied to intervention synchronicity criteria and did not include technological advancements that are more common in a laboratory setting or robotic devices created for mobility purposes.

Conclusions

Virtual exercise interventions are a relatively novel delivery for people with physical disabilities and mobility limitations. However, the results of this scoping review demonstrate promising results of virtual exercise interventions using different modalities and synchronicity strategies. Furthermore, these results also demonstrate the greater percentage of reported facilitators of participating and perceived benefits compared to reported barriers or perceived difficulties. Future studies should build upon these results by expanding disability criteria, age groups, and outcome measures. To our knowledge, this is the first scoping review to investigate assessment types of virtual exercise interventions among individuals with physical disabilities and mobility limitations.

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