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A Review of Virtual Reality Technology in Exercise Training for Older Adults

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Abstract

Regular physical activity has profoundly positive impact on an individual's physical and mental wellbeing. Older adults are recommended to engage in moderate-intensity physical activity for at least 30 minutes per day, and for three or more days per week. However, older adults may encounter various barriers which may lead to poor exercise compliance. In recent years, virtual reality (VR) technology has become increasingly popular in healthcare settings, with the aim to improve physical function, cognitive abilities, and mood in older people with chronic diseases. VR-based exercise may improve self-motivation in performing exercise, increase social interaction, and reinforces older adults' compliance to exercise training. The aim of this review is to evaluate the effectiveness of VR exercise and the potential advantages of incorporating VR-based rehabilitation for the aging population.

Keywords: Exercise; Virtual reality; Older adults; Chronic diseases; Diabetes

Introduction

The global elderly population of over 80-year-old has been estimated an increase from 126.5 million to 446.6 million between 2015 to 2050, more than doubling in this period [1]. Aging is the accumulation of changes over time in physical, psychological, behavioural, and social processes. It is a degeneration process that results in deterioration in body functions, which leads to an increase in risk of developing more than one chronic disease and thus an increased mortality rates [2]. Fall is one of the major health risks in older adults, which negatively impact their quality of life and it imposes a huge economic burden on the health-care system [3]. Maintaining muscle strength, gait stability, and balance control are vital for improving health and reducing risk of falls in older people especially for those with chronic diseases.

Regular exercises can improve general health status in older adults. It can not only improve their immune system and bone density but also have better control over their blood pressure and reduces the risk of developing cardiovascular disease [4-6]. Regular exercise can also build up muscle strength, improves flexibility, postural control, coordination, and balance, thus reduce risk of falling [7]. These benefits are particularly true for people with chronic diseases. For people with diabetes, common complications include peripheral neuropathy in the lower extremities, decline in balance performance and deterioration of the vestibular system, in which these factors increase their risk of falls [3]. Studies have shown that regular physical activity produces modest increments in physical fitness of diabetic subjects and reduces the risk of overall mortality twofold. Hence, physical activity should be an essential part of diabetes management to maintain optimal blood glucose, lipid, and blood pressure levels [8-10]. In terms of exercise protocols, studies have shown that a combination of aerobic and resistance training is more effective for blood glucose management as compared to either type of exercise alone [9].

Regular exercise is of paramount importance to older adults [4], however, many of them encounter difficulties in maintaining regular physical activity, especially when the benefit of exercise is not visible within a short period of time. The common barriers for older adults to adhere to regular exercises include low self-efficacy, lack of motivation, depressed mood, lack of interest, fear of falling, unsafe environment, personal health, physical ability, low expectations, socioeconomic status, inconvenient location, and inability to choose the correct type of exercise [11-14]. There are various strategies that can be adopted to improve exercise compliance in different client groups. Lee et al. suggested several strategies to increase self-efficacy, which includes performance accomplishments, vicarious learning, verbal encouragement,

physiological and affective status; in which these can initiate and maintain a positive physical activity behaviour [11].

Nowadays, virtual reality (VR) games are not only confined to the younger generations. There is a developing interest in older adults to attend VR-based rehabilitation program, which could potentially improve their exercise adherence [15]. The use of VR games with stereo televisions may enhance interaction and networking with their peers and increase enjoyment and satisfaction. Such technology could serve to promote health-relevant activities whilst encouraging social engagement and interaction, which thereby induce a positive attitude and behaviour change [16]. Another study showed that stroke survivors with limitation in activities of daily living can improve upper limb function by videogame-based training using VR technology [17]. However, this study has been excluded due to the enrolment of participants under the age of 65, which did not fulfil the inclusion criteria of the present review.

Exergaming is the term used for video game that can also be used as a form of exercise. It utilizes a VR environment to improve general physical fitness and for therapeutic purposes such as cardiac rehabilitation and neurorehabilitation. This could potentially bridge the gap between gaming and exercising, encouraging participation in physical activity. It also provides a real-time personalized virtual support from coaches and peers to improve behavioural adherence [18]. Depending on the targeted body movements, the resulting energy expenditure of exergames commonly varies from light to moderate [19].

VR holds great potential in enhancing treatment fidelity and offers an exciting aid in accelerating and sustaining behavioural change. As compared to VR, the immersive experience in augmented reality (AR) might further engage participants in the treatment process. In addition, the VR/AR environment provides an enjoyable experience for participants through personalized treatment program, which also encourages engagement in the intervention and offers unparalleled opportunity to enhance treatment enactment [18, 20]. On the other hand, the combination of training with VR not only induces benefits that conventional physical training has, but also provides immediate feedback that can facilitate motor learning and maximize therapeutic benefits. This can encourage patients to overcome their own limits in the pursuit of better performance [21]. Therefore, VR rehabilitation programmes can be conducted in line with current best practice for balance training in falls prevention [19,22].

The benefit of exercise is well-documented and has extensive evidence to support the effectiveness of VR exercises in improving physical, psychological, and social aspects of older adults [23]. Our mini review aims to summarize studies that evaluated the effectiveness of VR exercise in specific aspects including balance, mobility, cognitive function, mood and self-motivation, quality of life and social life in older adults.

Methods

Randomized controlled trials that implemented virtual reality interventions in older adults' rehabilitation were retrieved from seven electronic databases including healthcare related and psychological databases: CINAHL, EMBASE, MEDLINE, PubMed, Web of Science, Scopus and PsychINFO databases. Timeframe was set from 2000 to 2020, and the following search strategies were used: "Exercise" AND "Virtual reality" AND "Senior Adults" OR "Elderly" OR "Older Adults". An advanced search was conducted by adding key terms such as "Chronic diseases" OR "Diabetes". Studies that targeted older adult population (individuals over the age of 65 years old), published between 2000 and 2020 and in English with full text available are included. Studies that did not fulfill inclusion criterion and any duplicates from search were excluded.

Results

Study selection

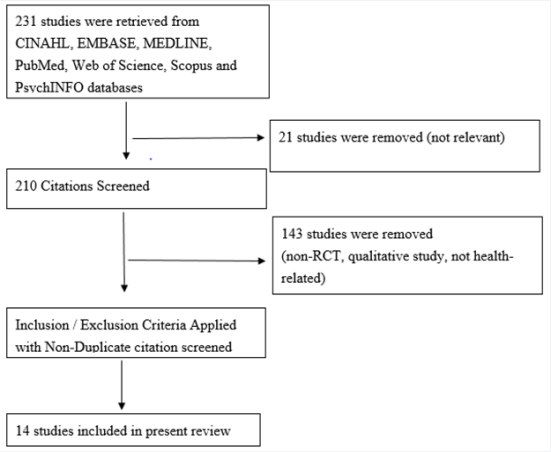

Figure 1: Selection process.

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A total of 14 studies (4 RCTs, 1 cross-sectional study, 1 pilot study and 8 quantitative studies) were selected for the purpose of this review. Three studies investigated the effects of exercise in older adults [4,24,25]; four studies examined the effects of virtual reality in the elderly cohort [7,20,26,27]; two studies explored the benefits of VR in obese/overweight individuals [16,18]; three studies illustrated the use of VR in other patient cohorts including Parkinson's, stroke, and haemodialysis patients [21,22,28]. Two studies evaluated the effectiveness of virtual reality in diabetic patients [9,10] (Figure 1).

Outcome measures have been categorized into five domains, including reduced falls risk and improved balance, mobility performance, enhanced cognitive function and social life. The study design, sample size calculation, outcome measures, and results are presented in Table 1.

Table 1: Data Summary of Studies.

	Authors & year of publication	Topics	Study Design	Sample size	Type of focus and features	Interventions	Outcome measures	Results	Conclusion
1	Chodzko-Zajko et al. [4]	Exercise & physical activity for older adults	Systematic review	269	Type and intensity of exercises for older adults.	Aerobic (AET) and resistance exercise (RET). Moderate-intensity activities for at least 30 mins or up to 60 mins, and for a total of 150-300 mins per week. Vigorous-intensity exercise, for 20-30 mins and for a total of 75-150 mins per week.	1) Muscular function 2) Cardiovascular function 3) Pulmonary function 4)Body composition/ Metabolism	AET & RET programs can increase aerobic capacity & muscle strength. Combination of AET & RET were more effective as compared either type of exercise alone. Acute effects of a single aerobic exercise session were relatively short-lived, and the chronic adaptations post repeated sessions quickly lost upon cessation of training.	Regular exercise induced positive physiological, psychological & cognitive effects.
2	Colberg et al. [9]	Exercise and Type 2 Diabetes - The American College of Sports Medicine and the American Diabetes Association: Joint position statement executive summary	Review	10	Effectiveness of virtual reality using video-game based technology in older adults with diabetes mellitus.	N/A	1) Acute effects of exercise 2) Chronic effects of exercise training	Regular aerobic training and resistance training can improve insulinization, which assists the management of blood glucose levels, lipids, blood pressure, thus reduces cardiovascular risk, lower mortality rate, and improve quality of life.	N/A
3	Lee & Shin [10]	Effectiveness of virtual reality using video gaming technology in elderly adults with diabetes mellitus	RCT	55 DM patients (over 65 years of age), VRE groups n= 27 and control group: n=28	VRE program would improve balance, strength, gait and falls efficacy in older adults with diabetes mellitus.	Video-game-based training (Duration: 50 mins per session, twice a week for 10 weeks).	1) Clinical tests for balance, strength, and gait 2) Questionnaires on falls efficacy	Significantly improved balance, decreased time needed for sit-to-stand, increased gait speed, cadence, and falls efficacy.	VRE program maximized the benefits of exercise by enabling players to fully immerse into the virtual environment. This also enhanced major influential factors in falls, in which reduces the risk of falls in older adults with type 2 diabetes mellitus.

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4	Scott et al. [27]	Assistive technologies to overcome sarcopenia in ageing	Review	N/A	Assistive technology (AT) and sarcopenia	Review on using 1) Walking aids 2) Wearable technology and smartphone/tablet applications 3) Video gaming and virtual reality 4) Emerging technologies for increasing physical activity and improving nutrition in functional decline cases.	1) Physical Activity 2) Nutrients	AT contributes to the maintenance of adequate levels of physical activity and nutrition in sarcopenic patients (both of which demonstrated a slow progression). Sarcopenia is a multifactorial condition and is associated with numerous other comorbidities and therefore AT alone is insufficient in the prevention of functional decline.	While AT may be beneficial for sarcopenic patients, clinicians should be aware of its potential limitations. Clinicians should preferentially prescribe AT devices to promote physical activity.
5	Arlati et al. [20]	A social virtual reality-based application for the physical and cognitive training of the elderly at home	Work presentation	N/A	The association between VR-based social application (Bike) and patient's motivation	Dual Task training program. User is required to cycle on a stationary bike while recognizing animal or object targets appearing along the way. Social network.	N/A	N/A	The social VR based game (bike) improves clinical outcomes of frailty, and promote social participation, which reduces the risk of falls. Personalized program would be ideal to enhance motivation and arousal levels in older adults.
6	Maynard et al. [21]	Effects of exercise training combined with virtual reality in functionality and health-related quality of life of patients on haemodialysis	RCT	n=40 (Intervention group: n=20 and control group: n=20)	Exercise training combined with Virtual Reality (VR) in functionality and Quality of Life	Performed VR-based endurance and strength exercises during haemodialysis (Duration: 12 weeks)	1) Functional capacity tests 2) HRQoL 3) Depression symptom	Exercise training improved functional capacity (TUG: P = 0.002, DASI: P < 0.001) and HRQoL. In physical and specific domains: physical functioning (P = 0.047), role physical (P = 0.021), as well as in physical composite summary (P < 0.001) and effects of kidney disease (P = 0.013). There was no influence on depressive symptoms (P = 0.154).	Physical training combined with VR improved functional capacity and have some changes in quality-of-life domains in haemodialysis patients.

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7	Rizzo et al. [16]	Virtual reality and interactive digital game technology: new tools to address obesity and diabetes	Review	N/A	VR and interactive digital game technology	Review on the use of VR games and VR technology.	N/A	Exergaming requires a significantly higher energy expenditure as compared to sedentary activities, and that is equivalent to amount of energy required for a brisk walk. However, these activities did not reach the level of intensity that would match playing an actual sport, nor do they satisfy the recommendation for children on daily doses of physical activity.	Digital exergames can be used as an additional tool in rehabilitation instead of acting as a replacement for regular physical activity.
8	Coons et al. [18]	The potential of virtual reality technologies to improve adherence to weight loss behaviours	Review	40	Virtual reality and weight loss program adherence	Suggest how virtual reality technologies might further improve the delivery, recipient, and enactment of program, to maximize intervention's impact on patient.	N/A	The potential technology-enhanced interventions improved fidelity and adherence to weight loss intervention. Virtual delivery on a smart phone can provide near and continual support and guidance for individuals.	VR-enhanced devices offered a platform for the population to fully engage in mastering new diet, activity, and self-regulatory strategies, which is the gateway to healthy weight regulation.
9	Lei et al. [22]	Effects of virtual reality rehabilitation training on gait and balance in patients with Parkinson's disease: A systematic review	A systematic review	16 papers with 555 participants	The effect of virtual reality on Parkinson's disease	VR rehabilitation program	Primary outcomes: (1) Gait (2) Balance function (3) Mobility. Secondary outcomes: (1) Global motor function (2) Activities of daily living (ADL) (3) Perceived confidence in balance (4) Neuropsychiatric symptoms (5) Cognitive function (6) Adverse events	Participants who undergone VR rehabilitation performed better than individuals in conventional or traditional rehabilitation in terms of the following three aspects: step and stride length, balance function, and mobility.	VR rehabilitation not only elicited same effects as conventional rehabilitation. It also has superior effect on balance and gait performance in patients with PD. Therefore, VR rehabilitation can be used as an alternative rehabilitation for individuals with PD.

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10	Mocanu et al. [26]	Mobile@Old: A smart home platform for enhancing the elderly mobility	Pilot study	n=19	The designing and implementation of Vital Signs Monitoring (VSM) and Physical Activity Trainer (PAT) components of Mobile@Old.	The purpose of PAT is to monitor individual's movement during physical activity. It computes the joint's relative positioning errors, which will then provide immediate visual feedback and guidance. VSM offers an online platform for medical professionals to monitor individual's condition, medication, and treatment plan. These two components together create a holistic approach for patient care.	Validity of vital sign, usability of platform using the System Usability Scale (SUS).	This study has concluded positive feedback from users. Users can feedback that the system is very personalized and commented these features have increased their motivation and enhanced their mobility.	Flexibility of exercises, interaction techniques and adaptation of therapeutic approach to the user's profile, medical condition, acquired progress and emotional state encourage older adults to use this system and to enhance their mobility.
11	Hsieh et al. [7]	The effectiveness of a virtual reality-based Tai Chi exercise program on cognitive and physical function in older adults with cognitive impairment	RCT	n= 60 (VRTC group: n=31, control group: n=29)	The cognitive and physical effects of a VR-based TC (VRTC) exercise program on older adults with cognitive impairment (CI).	VRTC exercise group participated in a 60-min session (10 mins warm up and 5 mins cool group session (Duration: 6 months, twice a week) Control group: Participant assigned to the control group were asked to maintain their usual daily physical activities.	1) Cognitive functions 2) Physical functions.	Significant interaction effects in the 6-min walk test, 30-s sit-to-stand test, functional reach, 5-m gait speed, abstract thinking and judgment. Overall, medium to large effect sizes (d = 0.50–0.82) were concluded.	The VRTC exercise posed a protective effect for some cognitive and physical functions in older adults with CI. The more engaging the program, the greater extent of improvement in cognitive performance.
12	Deutsch [28]	Using virtual reality to improve walking post-stroke: Translation to individuals with diabetes	Review	N/A	VR system protocol (hardware and software) and their applications on stroke patient	1) VR treadmill walking simulation 2) VR biking simulation 3) Resistant exercise	1) Dosage 2) Task 3) Gait measures	Three themes have been identified from this investigation: Virtual reality technology: 1) Hardware and software, 2) VR to improve walking, and 3) VR applications for people with diabetes and other conditions affecting ambulation. This study suggest that VR applications can be used for diabetic patients and for people with other medical conditions that could affect their ambulatory functions.	Suggestions on how current intervention for post-stroke patients might be translated to individuals with diabetes and other individuals with condition that might impair ambulatory conditions, this study has involved the target user groups (both practitioners and clients) early in the design and integration of activity and education into the systems.

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13	Eggenberger et al. [24]	Older adults must hurry at pedestrian lights! A cross-sectional analysis of preferred and fast walking speed under single- and dual-task conditions	A cross-sectional study	n=120 (65% female), younger group (age 70-79 years old): n=59, older group (age >80 years old): n=61	Cognitive and physical function	The testing protocol comprised single-and dual-task walking, in which subjects were instructed to walk under four different conditions: self-paced walking, at a faster walking speed, and each with or without a concurrent cognitive task (in addition to controlled speed).	1) Walking speed 2) The association between walking speed and functional lower extremity strength. Functional lower extremity strength was assessed using a 5-chair-rises test.	35.6% of older person were at the age of 70–79 years and almost three-quarters (73.8%) of individuals aged 80 cannot walk faster than 1.2 m/s, under cognitively challenging conditions (fast speed dual-task walking).	It has been concluded that fitness status of many older people is insufficient for crossing roads safely, especially for older adults living in urban areas of the community.
14	Anderson-Hanley et al. [25]	The Aerobic and Cognitive Exercise Study (ACES) for Community-Dwelling Older Adults with or At-Risk for Mild Cognitive Impairment (MCI): Neuropsychological, Neurobiological and Neuroimaging Outcomes of a Randomized Clinical Trial	RCT/ACES	n=111 (66% female & mean age of 78.1 years old) and exer-tour (n=46), exer-score (n=45), and game-only (n=20)	Cognitive benefits of physical exercise and brain health	Exer-tour: Physical exercise interactive with relatively passive, low cognitive load, virtual scenario bike tour. Exer-score: physical exercise interactive with a relatively effortful, high cognitive demand, video game only. Same video game operated by joystick or keyboard (Duration: 6 months, twice a week, 20-40 mins).	1) Executive function 2) Memory 3) Everyday cognitive function	Executive function improved after 6 months of intervention. Both the exer-tour and exer-score conditions yielded statistically significant moderate effects by 6M (d=0.52 and 0.47, respectively). Exer-tour condition appeared to yield benefit sooner than exer-score.	For a more impaired MCI population, the benefit of exer-tour shows up by three months, however, it may be necessary for participants to adhere to such interactive exercises for a longer period (6 months) to master the challenges and achieve its long-term effects.

VR Exercise Reduces Falls Risk and Improves Balance Performance

Aging and diabetes complications are common risk factors of falls. Falls can be caused by reduced muscle strength or muscle atrophy, which results in declined functions in the lower extremities. Jin et al. [29] proposed a multi-barycentric area model (MBAM) to examine human balance capacity based on visual stimulation under VR environment. This model describes body balance condition by computing center of gravity using a triangle area surrounded by upper, middle, and lower parts of the body. The analysis of projection coordinates from the triangle can provide objective measures of balance dysfunction and therefore a more accurate data on an individual's balance ability. This proposed research has provided valuable results for future investigations in adopting such classification in patients with balance dysfunction and potentially applicable to an extensive cohort of patients such as stroke and multiple sclerosis individuals. VR-based exercise can be easily translated into appealing, easy applicable, and potentially cost-effective videogame-based training regimes or intergenerational balance training targeting falls prevention in older adults [4,10,19,22].

In recent years, VR technology plays an important role in exercise training of balance performance. Findings showed that playing VR games can improve Berg Balance Scale (BBS) scores and extend the stability limits of institutionalized and frail older adults with history of falls [6,12,20,22]. Video games are considered as a new nonmedical intervention for elderly, allowing them to maintain good health conditions by engaging in regular physical and cognitive exercises [20,26]. The use of VR games is not only limited to the older adult population, but it is also evident that fully immersive VR training systems can also bring positive impact to cardiovascular and muscular parameters in young healthy population [30]. Many studies have examined the potential benefits for VR amongst older population and has concluded the implementation of VR in balance training to be effective for falls prevention [19,22,29].

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VR-based Exercise Improves Mobility Performance

Sensory inputs are essential for initiating any movements, in which VR exercise provide an opportunity to integrate motor and sensory system to interact with video-game based exercise. The reaching component can be used to assess an individual's ability to move through the entire range of their body. Upper-limb sensorimotor function can be assessed using visually guided reaching, as it requires input from both sensory and motor system. This can improve the full spectrum of physical functioning, from finest finger motions to gross movements involving the whole body [31].

Mocanu et al [26] proposed a smart home platform to enhance mobility in older adults, using two core components, namely Physical Activity Training (PAT) and Vital Signs Monitoring (VSM). This platform is designed to tackle the major barrier to physical activity in older adults that is adherence to exercise program. The purpose of PAT is to monitor individual's movement during physical activity. It computes the joint's relative positioning error, which will then provide immediate visual feedback and guidance for correction. VSM offers an online platform for medical professionals to monitor individual's condition, medication, and treatment plan. These two components together create a holistic approach for patient care. This study has concluded positive feedback, where users have reported system to be very personalized and have commented that these features have increased their motivation and enhanced their mobility [26]. Similarly, in another study that explored the effectiveness of Online-Gym concluded consistent results, where specifically found improved hand-eye coordination and delayed onset of memory decline in older adults.

Hsieh et al. [7] conducted a study to explore the cognitive and physical effects of VR-based Tai Chi program on older adults with cognitive impairment. Exercise regimes consist of tasks that progressively gets more complex and covers essential activity of daily living. Outcome measures used in this study assessed both cognitive and physical components; including 6-min walk test, 30-s sit-to-stand test, functional reach, 5m / sec gait speed, abstract thinking, and judgment. The VR-based Tai Chi group showed significant improvement in these assessed components, demonstrating a positive effect on their level of fitness.

VR-based Exercise Enhances Cognitive Function

Virtual environment utilized in a video-game setting could educate patients regarding lifestyle management, medication, and nutrition in addition to physical activity. This addresses both cognitive and physical elements of rehabilitation [28]. Crossing road, for example, it provides an opportunity for user to navigate through virtual scenes to mimic everyday life under a controlled environment. Extensive evidence has demonstrated that VR-based exercise enhances cognitive function in older adults. Hsieh et al [7] have also explored the effects of VR-based Tai Chi exercise program on cognitive function of older adults. The VR-based Tai Chi exercise showed a protective effect for cognitive and physical functions in older adults with cognitive impairment.

The more engaging the program, the greater extent of physical and cognitive improvement elicited. The exercise program was delivered twice weekly for 6 months. The duration of each training session varied from 20 to 120 minutes; the frequency varied from 1 to 4 times per week with the overall training program lasted for 4 weeks to 1 year. Participants attended two sessions of 45–60-minute training weekly, in which results have shown significant improvements in balance but no change in lower extremity endurance after three months of VR intervention. It is important to take note that it took at least six months to obtain significant protective effects for other assessed components, such as cognitive function, cardiopulmonary endurance, and mobility function. Therefore, the overall duration of exercise program is recommended to last for at least 6 months to achieve all potential cognitive and physical benefits [7].

VR Exercise Improves Quality of Life, Mood and Self-Motivation

VR-based exercise and social media have been proposed to be promising strategies in increasing users' motivation and thus their willingness to practice. Research have suggested social media can help overcome boredom and spark the desire to continue physical activity. Family members and friends can share their experience and enjoyment on social media platform, specifically aiming to encourage inclusion of elderly population. Regular physical activity can also improve sleep quality by increasing sleep duration, and thus wake up feeling more energetic and refreshed [20]. Interactive VR games and exercises has opened a new horizon for community dwelling older adults to explore and to foster positive health attitudes.

Research has found that elderly people walk at a slower speed and tire more quickly owing to the loss of strength and mass in lower extremities. Slow walking speed not only correlates with adverse health outcomes, but it also increases the risk of traffic accidents for older people walking in urban areas. Therefore, VR exercises may incorporate appropriate functional training targeting pedestrian safety to reduce risk of traffic accident. Eggenberger et al [24] conducted a cross sectional assessment on walking speed and has observed inadequate fitness level in majority of community-dwelling older patients, putting them at risk at crossroads. This study has suggested training measures aiming to improve elderly population's cognitive and physical fitness, has positive impact on their walking speed, mobility, and safety [24].

VR has been proven to be an effective strategy in therapeutic programs. Combining exercise training with VR technology enables playful, interactive work and accurate feedback, facilitating patient's interest and probable adherence to treatment program [21]. Simulating outdoor activities and travelling abroad

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in VR environment seem to be appealing to older adults who have physical and/or financial limitation. VR cycling, for example, spatial navigation while cycling is now feasible and that older adults have reported similar enjoyment as to younger adults. This technology can continuously motivate older adults to engage in exercises by progressing into different VR scenario, based on their performance and ability [25].

Maynard et al. [21] reported VR training therapy can minimize depressive symptoms. VR training reinforces goal achievement by providing real-time and objective feedback, in which the discrepancies between current performance and targeted goals can be visualized. The application is customized to facilitate accountability and social support from coaches and peers for self-monitoring [18]. Some of them expressed their motivation to maintain regular exercise is to stay fit for their favourite sport or for keeping up with their grandchildren [13]. The goal is to maximize older adults' level of independence in activities of daily living, which therefore enhance their quality of life.

VR Exercise Promotes Social Participation

Group exercise seems to be a better alternative as compared to doing it alone, since people may feel more supported and motivated when exercising with peers. During VR exercise, older adults can fully immerse into the virtual environment; this can increase their level of motivation and arousal, which enhances their performance as well as their adherence to exercise program. Various studies have demonstrated VR exercise to be effective in reducing the risk of falling, through the improvement of frailty indicators, which can subsequently promote social participation. Therefore, it appears to be interesting in evaluating whether the customization of avatars' characteristics, perhaps through a reward mechanism, enhances older adults' participation and engagement in physical activity [20].

Dancing has a dual task character, which potentially stimulates physical and cognitive functions simultaneously. The RCT research proposal hypothesized that dancing has superior effect on improving executive function (e.g., memory, flexible thinking) as compared to physical exercise alone or through exergaming, however there is no evidence available so far [32]. Combining exercise with socialization can make a difficult task easier; it has been shown that older adults who perform physical activity with peers or in groups tend to have better exercise compliance. They enjoy having conversations whilst exercise and that they may perceive time goes by quicker than usual.

Discussion

Aging often leads to various health problems and that can reduce social engagement and have an impact on individual's mental wellbeing. There are many barriers to physical activity in older adults, which by far, lack of interest is the major factor. It is therefore essential to find innovative methods to motivate older adults to participate in exercise program. VR-based exercise may potentially be a solution to this barrier, as it has been proven to encourage older adults' self-motivation. This review has evaluated the effectiveness of VR-based exercise in improving balance, mobility, cognitive function, mood and self-motivation, quality of life and social life in older adults. VR exercise training may also contribute to improvement in emotional and social well-being of older adults. Exercise program usually last for 8 weeks or longer, where the dropout rate is usually high owing to low compliance. With the implementation of VR technology, exercise program is more enjoyable and older adults are more likely to adhere to it. VR-based exercise program may also promote physical activities in older adults with chronic diseases, where improvement in physical and cognitive function can allow them to live more independently. This review has highlighted encouraging findings from previous VR-based exercise studies, but a limited number of randomized controlled trials has been conducted on the therapeutic effects of VR-based exercise in people with chronic diseases. More rigorously designed methodology with standardized interventions, larger sample size and multi-centred randomized controlled trials are needed to provide stronger evidence to verify the potential advantages of VR-based exercise [22].

Older adults are recommended to engage in moderate-intensity exercise, including muscle-strengthening activities of all major muscle groups for at least 30 minutes, three days per week [14,19,22,33]. Typical exercise training includes progressive weight training programme, weight bearing calisthenics, stair climbing and other strengthening exercises. Stretching exercise is also recommended to be conducted twice a week. Note that the above recommendations on physical activities should be adjusted accordingly depending on the individual's ability. Particular attention should be paid to elderly with chronic diseases, such as diabetes, hypertension, osteoarthritis, osteoporosis, and cardiovascular diseases. Recently, Lee & Shin [10] found that VR exercise program for older adults with diabetes elicited significant improvement in muscle strength, gait, balance and falls efficacy. Interactive video gaming and VR gaming provided new platforms for the delivery of exercise programs [27]. Colberg et al. [9] reported people with diabetes who performed resistance or aerobic exercise alone have improved their overall glycaemic control. However, for subjects who undergone a combination of aerobic and resistance training, they demonstrated a more effective glycaemic control and a significantly lower HbA1c value as compared to those who performed either type of exercise alone [8,9].

While this mini review has established the physical, mental, and social benefits of VR-based exercise on older adults, some older adults find it difficult to adhere to physical activity, especially when the benefit of exercise is not visible within a short period of time. Exergames make use of VR to create an ecological and controlled environment specifically designed to challenge users. VR is interactive and immersive, which makes physical activity more appealing and more enjoyable for users [21,26]. It provides

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real-time visual feedback to allow self-correction of motion, which studies have documented valuable therapeutic effects in balance rehabilitation. It has been concluded that exergame has the potential in increasing adherence to treatment and enhancing exercise compliance in older adults [3,20,22].

Furthermore, the use of VR chart to record metrics and track progress of training is helpful by providing quantitative results for older adults, which may encourage them to work harder and prevent drop-outs due to perceived lack of progress. The implementation of novel technology may increase their level of arousal and motivation and motivate them to maintain active lifestyle. In addition, by avoiding the same exercise routine can reduce boredom. User will receive positive visual reinforcement when correct task achieved and this can often intensify the connection between enjoyment and exercise. VR cycling, for instance, may encourage participants to cycle with peers whilst enjoying the stimulated scenarios displayed on the VR system. Various interventions have been explored to improve exercise adherence in older adults; it has been concluded that more feedback and monitoring would promote exercise adherence [34]. VR-based exercise also makes good use of visual and auditory feedback, and these can be useful strategies in encouraging older adults to adhere to physical activity. Future studies can examine whether VR-based exercise can improve exercise compliance for older adults to consolidate this statement.

Conclusion

Virtual reality-based exercise is an interactive and innovative technology to be implemented into exercise program for older adults. Performing exercise with peers through competitive VR games may increase their motivation and satisfaction and therefore increase their exercise compliance. VR exercise can improve balance and mobility that may subsequently reduce the risk of falls. In addition, VR exercises also have a positive impact on cognitive function, quality of life, mood and self-motivation and social life. All the above highlighted positive impact of VR exercises is especially beneficial for older adults with chronic illnesses. Optimized physical health is vital for maintaining independence and quality of life for older adult in this aging population.

References

1. World Health Organization (2015) World report on ageing and health. In: World Health Organization, Geneva, Switzerland.
2. Flatt T (2012) A new definition of aging? Front Genet 3: 148.
3. Grewal GS, Sayeed R, Schwenk M, Bharara M, Menzies R, et al. (2013) Balance rehabilitation: Promoting the role of virtual reality in patients with diabetic peripheral neuropathy. J Am Podiatr Med Assoc. 103(6): 498-507.
4. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, et al. (2009) Exercise and physical activity for older adults. Medicine and Science in Sports and Exercise 41(7): 1510-1530.
5. Palombaro KM, Black JD, Buchbinder R, Jette DU (2013) Effectiveness of exercise for managing osteoporosis in women postmenopause. Phys Ther 93(8): 1021-1025.
6. Moreira LD, Oliveira ML, Lirani-Galvao AP, Marin-Mio RV, Santos RN, et al. (2014) Physical exercise and osteoporosis: Effects of different types of exercises on bone and physical function of postmenopausal women. Arq Bras Endocrinol Metabol 58(5): 514-522.
7. Hsieh CC, Lin PS, Hsu WC, Wang JS, Huang YC, et al. (2018) The effectiveness of a virtual reality-based tai chi exercise on cognitive and physical function in older adults with cognitive impairment. Dement Geriatr Cogn Disord 46(5-6): 358-370.
8. Di Loreto C, Fanelli C, Lucidi P, Murdolo G, De Cicco A, et al. (2003) Validation of a counseling strategy to promote the adoption and the maintenance of physical activity by type 2 diabetic subjects. Diabetes Care 26(2): 404-408.
9. Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, et al. (2010) Exercise and type 2 diabetes: The American College of Sports Medicine and the American Diabetes Association: joint position statement executive summary. Diabetes Care. 33(12): 2692-2696.
10. Lee S, Shin S (2013) Effectiveness of virtual reality using video gaming technology in elderly adults with diabetes mellitus. Diabetes Technol Ther 15(6): 489-496.
11. Lee L-L, Arthur A, Avis M (2008) Using self-efficacy theory to develop interventions that help older people overcome psychological barriers to physical activity: A discussion paper. Int J Nurs Stud 45(11): 1690-1699.
12. Hill AM, Hoffmann T, McPhail S, Beer C, Hill KD, et al. (2011) Factors associated with older patients' engagement in exercise after hospital discharge. Arch Phys Med Rehabil. 92(9): 1395-1403.
13. Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE (2014) Barriers to and facilitators of physical activity program use among older adults. Clin Med Res 12(1-2): 10-20.
14. Picorelli AMA, Pereira LSM, Pereira DS, Felício D, Sherrington C (2014) Adherence to exercise programs for older people is influenced by program characteristics and personal factors: A systematic review. J Physiother 60(3): 151-156.
15. Kelley GA, Kelley KS (2013) Dropouts and compliance in exercise interventions targeting bone mineral density in adults: a meta-analysis of randomized controlled trials. J Osteoporos 2013: 250423.
16. Skip Rizzo A, Lange B, Suma EA, Bolas M (2011) Virtual reality and interactive digital game technology: New tools to address obesity and diabetes. J Diabetes Sci Technol 5(2): 256-264.
17. Vanbellingen T, Filius SJ, Nyffeler T, van Wegen EEH (2017) Usability of videogame-based dexterity training in the early rehabilitation phase of stroke patients: A pilot study. Front Neurol 8: 654.
18. Coons MJ, Roehrig M, Spring B (2011) The potential of virtual reality technologies to improve adherence to weight loss behaviors. J Diabetes Sci Technol 5(2): 340-344.
19. Donath L, Rossler R, Faude O (2016) Effects of virtual reality training (exergaming) compared to alternative exercise training and passive control on standing balance and functional mobility in healthy community-dwelling seniors: A meta-analytical review. Sports Med 46(9): 1293-1309.
20. Arlati S, Colombo V, Spoladore D, Greci L, Pedroli E, et al. A social virtual reality-based application for the physical and cognitive training of the elderly at home. Sensors (Basel) 19(2): 261.
21. Maynard LG, de Menezes DL, Liao NS, de Jesus EM, Andrade NLS, et al. (2019) Effects of exercise training combined with virtual reality in functionality and health-related quality of life of patients on hemodialysis. Games Health J 8(5): 339-348.
22. Lei C, Sunzi K, Dai F, Liu X, Wang Y, et al. (2019) Effects of virtual reality rehabilitation training on gait and balance in patients with Parkinson's disease: A systematic review. PLoS One 14(11): e0224819.

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23. Fahrenkamp A, Benore E (2019) The role of heart rate variability biofeedback in pediatric chronic pain rehabilitation: A case series design. Clinical Practice in Pediatric Psychology 7(4): 358-370.

24. Eggenberger P, Tomovic S, Münzer T, de Bruin ED (2017) Older adults must hurry at pedestrian lights! A cross-sectional analysis of preferred and fast walking speed under single- and dual-task conditions. PLoS One 12(7): e0182180.

25. Anderson-Hanley C, Barcelos NM, Zimmerman EA, Gillen RW, Dunnam M, et al. (2018) The aerobic and cognitive exercise study (ACES) for community-dwelling older adults with or at-risk for mild cognitive impairment (MCI): Neuropsychological, neurobiological and neuroimaging outcomes of a randomized clinical trial. Front Aging Neurosci 10: 76.

26. Mocanu I, Schpor OA, Cramariuc B, Rusu L (2017) Mobile@Old: a smart home platform for enhancing the elderly mobility. Advances in Electrical and Computer Engineering 17(4): 19-26.

27. Scott RA, Callisaya ML, Duque G, Ebeling PR, Scott D (2018) Assistive technologies to overcome sarcopenia in ageing. Maturitas 112: 78-84.

28. Deutsch JE (2011) Using virtual reality to improve walking post-stroke: Translation to individuals with diabetes. J Diabetes Sci Technol 5(2): 309-314.

29. Jin H, Xie L, Xiao Z, Zhou T (2019) Classification for human balance capacity based on visual stimulation under a virtual reality environment. Sensors (Basel) 19(12).

30. Feodoroff B, Konstantinidis I, Frobose I (2019) Effects of full body exergaming in virtual reality on cardiovascular and muscular parameters: Cross-sectional experiment. JMIR Serious Games 7(3): e12324.

31. Cunningham D, Krishack M (1999) Virtual reality promotes visual and cognitive function in rehabilitation. Cyberpsychol Behav 2(1): 19-23.

32. Himmelmeier RM, Nouchi R, Saito T, Burin D, Wiltfang J, et al. (2019) Study protocol: Does an acute intervention of high-intensity physical exercise followed by a brain training video game have immediate effects on brain activity of older people during stroop task in fMRI? A randomized controlled trial with crossover design. Front Aging Neurosci 11: 260.

33. Bennett JA, Winters-Stone K (2011) Motivating older adults to exercise: What works? Age Ageing 40(2): 148-149.

34. Peek K, Sanson-Fisher R, Mackenzie L, Carey M (2016) Interventions to aid patient adherence to physiotherapist prescribed self-management strategies: A systematic review. Physiotherapy 102(2): 127-135.

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