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Comparison of an Eight-week Training Program with and without Virtual Reality on Motor and Cognitive Performance of Women with Multiple Sclerosis

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A B S T R A C T

Background: This study compared the effect of training programs with and without virtual reality (VR) on the motor and cognitive performance of women with Multiple Sclerosis (MS). **Methods:** It was a Quasi-experimental study with two experimental groups (17 participants in each group) and a control group (15 participants). Participants have Relapsing-remitting multiple sclerosis and were 20 to 40 years old, and living in Amol City. There were three groups: the experimental group exercised with VR (T+VR), the experimental group exercised without VR (T), and the control group didn't have any exercise intervention. The exercise intervention was carried out for eight weeks (twice a week) including five stages: warming up the body, walking on a treadmill, resting, soccer goalkeeping, and cooling down. The tools used for pre-test and post-test measurement were: Expanded Disability Status Scale Borg Rating of the Perceived Exertion, timed 25-Foot Walk Test, Berg Balance Scale, Timed Up and Go Test, Fatigue Severity Scale, Depression, Anxiety and Stress Scale Questionnaire, Mini-Mental State Examination test, Tower of London test. Analysis of covariance and Bonferroni pairwise comparison was used for data analysis. **Results:** The results showed that the eight-week exercise program with and without VR effectively increased static and dynamic balance and improved the mental state of women with MS ($P<0.05$), But no significant difference was observed between the two groups in comparison to the control group. Also, the training program with and without VR affected improving walking speed, reducing the intensity of fatigue, stress, anxiety, and depression, and increasing the problem-solving ability of women with multiple sclerosis ($P<0.05$). This effectiveness in the T+VR group was more than in the T group. **Conclusion**: Performing sports training with and without VR has a significant effect on the motor and cognitive performance of women with multiple sclerosis, but training with VR can be a motivating and effective alternative for the motor and cognitive rehabilitation of women with multiple sclerosis.

1. Introduction

Multiple Sclerosis (MS) is an autoimmune, inflammatory, and chronic disease that manifests in the form of a damaged myelin sheath on the nerve fibers in the white matter of the brain, spinal cord, and optic nerves (Mir et al. 2018). The pathological cause of this disease is unknown, and according to global statistics, estimated that three million people worldwide are affected by MS (Lozano-Quilis et al. 2014), which is mainly diagnosed between the ages of 20 and 50 and affects women twice as much as men. Among the most common weaknesses and limitations in motor performance in MS patients, we can mention imbalance or postural fluctuation (Yazgan et al. 2020), reduced walking ability (Sheikholeslami-Vatani and Ghaderi, 2019), reduced movement speed (Fjeldstad et al. 2009), and fatigue (Penner et al. 2020). In addition to the limitations in motor performance, patients with MS suffer from cognitive weaknesses such as impaired visual organization (diplopia and optic neuritis), visual-spatial perception, mental processing, problem-solving (Jonsson et al. 2006), abstract thinking, memory (Ernst et al. 2020), attention, slowness of information processing (Patti et al. 2010), and learning (Raghibi and Khosravi, 2012).

Virtual reality (VR) is a new MS patient treatment method that offers targeted and frequent exercises, clinical environment simulations, and personalized feedback. It allows for continuous adaptation to individual abilities and can be done from home at any time (Ozkul et al. 2020; Laver et al. 2017). The number of studies using video game consoles in the field of motor rehabilitation has increased (Ortiz-Gutierrez, 2013), and the results have shown that intense and repeated training in an individual interactive context leads to promising results in improving performance in patients with various neurological diseases, including MS (Calabro et al. 2017). Especially patients who have progressed in motor and cognitive impairments have faced a positive perception of their performance compared to traditional rehabilitation exercises (Novak and Riener, 2013). Although training programs based on VR have shown

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promising results in neurological diseases, there is little evidence for them (Fulk, 2005). So, more research is needed to examine all aspects of it (Peruzzi et al. 2016) because the future of VR in treatment and rehabilitation is not precisely defined, and no one knows where this science is going. But it must be accepted that VR has entered the field of treatment and rehabilitation, and it is developing amazingly (Faryabi, 2014).

One of the most debilitating physical symptoms in MS patients has poor balance and posture. In a meta-analysis based on little research evidence, Castellano-Aguilera et al. (2022) found that VR-based treatments are more effective than no intervention or conventional rehabilitation in improving balance and risk of falling in people with MS. In a meta-analysis, Santos Nascimento et al. (2021) confirmed that the effect of using VR in improving balance was equal to or greater than conventional exercises in people with MS. Ozkel et al. (2020) concluded that balance training through immersive VR had beneficial effects on balance, mobility, and fatigue in patients with MS. Studies showed that VR training improving the balance of MS patients (Maggio et al. 2019; Casuso-Helgado et al. 2018). Along with balance, walking speed is another important variable for MS patients (Seifadini Zarandi et al. 2016). To prevent falling while walking and increase balance, such patients walk at a slower speed, take shorter steps, spend a greater percentage of their movement pattern in the double support phases, and they take wider steps to increase their reliance level (Sosnoff and Sandroff, 2012). They also experience fatigue which greatly affects their walking endurance (Socie and Sosnoff, 2013). Patients with MS describe the nature of fatigue as an increased or progressive weakness during the day or as a constant and persistent abnormal feeling of tiredness (Motaharinezhad et al. 2015). Winter et al. (2021) found that for patients with MS and stroke, treadmill training with VR is more effective than treadmill training without VR. Hsieh et al. (2020) found that people with MS who used a training protocol with VR had a significant increase in their walking speed compared to the group that trained without VR. Maggio et al. (2019), in a meta-analysis between 2010 and 2017, found that following the use of VR, patients with MS had a significant improvement in movement (especially walking).

MS patients also suffer from various impairments in cognitive performance. Cognitive performance is a term that refers to a person's ability to perform various mental activities, from processing the most detailed sensory processes to the most complex level of thinking, which includes recognition, recall, learning, problem-solving, remembering (memory), and attention. Lack of independence, autonomy, and failure to perform daily activities lead to a decline and decrease in cognitive performance (Bayrami et al. 2015). VR training has positive effects on cognitive performance such as information processing speed (Hsieh et al. 2020), concerning executive abilities and visual-spatial, attention, and memory skills (Maggio et al. 2019).

The treatment of people with MS with VR puts people in a good psychological position and appropriate physiological reactions to face and deal with tension, depression, and anxiety. Because it is concluded that more engagement and involvement of patients do not allow them to think about the disease, so this may be one of the reasons for the reduction of depression in this type of patient. Saladino et al. (2023) concluded that neurorehabilitation treatment based on VR in patients with MS is an effective tool that helps improve quality of life and mood. In a meta-analysis, Santos Nascimento et al. (2021) confirmed that the effect of using VR in improving the quality of life was equal to or greater than conventional exercises in patients with MS.

Although the neurological, physiological, and behavioral evidence support the effectiveness of the treatment through movement computer games on cognitive variables, the magnitude of this effect is unclear. In other words, due to the lack of standard and well-controlled methodology, the causal inference of this relationship will be very limited (Jalili et al. 2019). On the contrary, the results of some other research in the above field have shown that the use of VR in motor and cognitive rehabilitation of patients with MS has not brought much difference compared to traditional rehabilitation exercises. For example, Casuso-Holgado et al. (2018) found that balance training with VR did not show a significant overall effect compared to conventional training in people with MS. Also, in the case of walking rehabilitation with VR, no effective result was observed, and the final result stated that VR training can be considered as a common and conventional exercise that is merely more effective than no intervention. Despite the reported studies, technological tools in the field of rehabilitation, such as VR, have not yet been widely used due to insufficient research. Therefore, more and more detailed investigations of the feasibility and effectiveness of rehabilitation exercises with VR in patients with MS should be considered by researchers (Manuli et al. 2020). Although the use of VR programs, which are specific for rehabilitation applications, is not common in clinical environments, game consoles are everywhere (Rizzo and Koenig, 2017), and since the interaction between humans and computers is expanding every day in every part of the world, it definitely as a very useful treatment method will be welcomed. And it even makes the science of rehabilitation in both motor and cognitive dimensions able to provide useful solutions for countless situations (Eslami et al. 2014).

It seems that examining a training program using VR can improve the existing knowledge in the organization of training programs and have significant benefits for improving the motor and cognitive performance of patients with MS. In addition to the development of scientific and theoretical aspects, the finding of this type of research will further show the practical role and importance of healthcare programs. In a way that potentially provides an opportunity for patients to be actively involved in rehabilitation, and without relying on others, can move for a longer period and prevent the possible occurrence of damage due to the progress of the disease. The daily life of MS patients requires both movement and cognitive abilities. However, traditional rehabilitation often faces problems. Currently, innovative VR technology is being tested to improve the abilities of MS patients. Studies in this field are limited and existing studies have contradictory results, only focusing on limited aspects of motor or cognitive abilities. This study aims to answer the question: What is the effect of an eight-week exercise program, with and without VR, on the motor and cognitive performance of women with MS?

2. Materials and Methods

2.1. Subjects

The current research was applied research with a quasi-experimental research method, which was conducted as a pre-test and post-test with two experimental groups and one control group. All experiments were done following the ethical principles and the national norms and standards for conducting medical research in Iran. The statistical population group included all women with relapsing-remitting MS aged 20 to 40 living in Amol City. The sampling method was purposeful and convenient, and the sample size was determined using GPower software (with 80% test power, an effect size of 0.5, and a confidence interval of 0.95) 45 women with MS. Four additional participants were included to the possibility of drop-out the participants. Two experimental groups (17 subjects in each group) and a control group (15 subjects) were considered to have entered the study voluntarily and were divided by a simple random allocation method. In the classification of groups, the first group consisted of exercises with VR (T+VR), the second group consisted of exercises without VR (T), and the third group was without any exercise intervention (control group). Women with MS were invited to undergo screening tests. Methods included sending a letter to the MS Association of Amol City, distributing an introduction form among neurologists in Amol City,

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and inviting the subjects. The registered subjects were called to one of the gymnasiums located in Amol city to complete the steps of entering the research, such as final registration, completion of informed consent, medical examinations by a neurologist, and completion of the brief psychological examination questionnaire.
For inclusion in the present study, female subjects aged 20 to 40 must have a definite diagnosis of MS according to the modified McDonald criteria (2010) by a neurologist, a minimum MS duration of 6 months, an EDSS score between 1 and 5, no recurrence of the disease, no use of anti-inflammatory drugs for anxiety and depression for at least two months prior to the start of the study, no history of participating in VR exercises, and the occurrence of severe and sudden neurological symptoms within two months prior to the study. Exclusion criteria from the study included acute problems in the patient, lack of consent to continue cooperation, receipt of psychological or rehabilitation treatments during the exercise period, and absence of three sessions for the experimental group. Table 1 provides descriptive information about the subjects, including their age, height, weight, and degree of disability.

Table 1:
Descriptive information about the age, height, weight, and degree of disability of subjects

Variable	Groups	M	SD	Minimum	Maximum
Age (years)	T+VR	30.53	4.42	24	38
	T	33.06	4.52	25	40
	Control	31.33	4.40	25	40
Height (Cm)	T+VR	165.73	5.75	157	174
	T	165.46	6.89	158	175
	Control	165.40	5.52	155	174
Weight (Kg)	T+VR	68.86	6.18	57	80
	T	64.66	7.34	51	76
	Control	65.73	6.74	52	76
A state of extensi disability	T+VR	3.13	.63	2	4
	T	2.86	.61	2	4
	Control	3.33	.44	2.50	4

2.2. Apparatus and Task

The extended disability status scale was used to measure the severity of the patient's disability and the measurement tools used in the pre-test and post-test were: (1) Standing height meter to measure the height of subjects. (2) digital weighing scales to measure subjects' weight. (3) Timed 25-Foot Walk test to measure walking speed: the temporal reliability of this test was confirmed by Learmanth et al. (2012) as 0.94. (4) Berg Balance Scale (BBS) to measure the static balance: the temporal reliability was obtained by Berg et al (1992). through retesting in inter-examiner and intra-examiner modes, respectively, 0.98 and 0.99, and internal reliability was also obtained by Cronbach's alpha coefficient showed a value of 0.96 (Kashani et al., 2016). (5) The Timed Up and Go Test to measure dynamic balance: the temporal reliability was confirmed by Learmanth et al. (2012) as 0.97. (6) The Fatigue Severity Scale (FSS) questionnaire to measure the intensity of fatigue: the temporal reliability was confirmed by ten nursing professors of Tarbiat Modares University and Tehran University with the retest method of 0.83 (Ebrahimi Atari et al., 2011). (7) The Borg Rating of Perceived Exertion (RPE) scale to measure exercise intensity. (8) Depression Anxiety Stress Scales (DASS) questionnaire to measure depression, anxiety, and stress: reliability of this test in Iranian non-clinical sample, through internal consistency for depression scale 0.93, and anxiety and stress 0.90 and its reliability through examination of retest coefficients for Three scales are estimated at 0.84, 0.89 and 0.90 respectively (Zamani et al., 2012). (9) Mini-Mental State Examination (MMSE) to measure orientation, attention and calculation, close memory, and visual-spatial thinking: the internal reliability of this test by Kazemi et al. (2023) using Cronbach's alpha coefficient for the whole test is 0.89 was approved. (10) Tower of London test to measure problem-solving ability: the validity of this test is accepted and reported as 0.79 (Birami et al., 2014).

2.3. Procedure

The exercise program with and without the use of VR glasses was designed to increase the motor and cognitive abilities of the subjects for eight weeks and two sessions each week. It should be noted the training duration started at 35 minutes in the first week and reached 70 minutes following a five percent increase in the eighth week. Each training session with and without VR is divided into five stages: (1) warming up and doing general body stretching movements, (2) walking on a treadmill, (3) resting, (4) soccer goalkeeping, (5) stretching exercises, and finally, relaxation exercises to cool down. Before the start of the training program, an introduction session was held to familiarize the subjects with the two training methods used in the present studyThe training program used in the present research is a combination of the training program of two studies by Hsieh et al. (2020) and Ozkul et al. (2020). Hsieh et al. (2020) study combined cognitive-motor virtual reality training on MS symptoms compared to conventional treadmill training, and in Ozkul et al. (2020) study used football game immersive training. in the present study to compare the results of two training methods with and without VR. The subjects in the control group also did not receive any intervention, and they were asked to maintain their daily activity level and not participate in any training program.

The T + VR group used VR glasses, a head-mounted display with the Chinese brand Oculus Quest 2, which is purposefully developed to provide a VR environment while watching the VR environment. The participants performed the introduced exercise program in a virtual environment with visual attractions. The T+VR group was as follows: the subjects first warmed up and performed general stretching movements of the body, then they performed the selected exercises of walking on a treadmill and soccer goalkeeping. Finally, stretching and relaxation exercises were done to cool down. At the same time, by walking on a treadmill, a subject could see and feel his presence in 3D images of various natural landscapes using VR and listening to music. The speed and incline of walking on the treadmill for each session followed an increasing trend (low speed

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and low incline to high speed and high incline) according to the abilities of each subject. Increasing the intensity of the exercises was evaluated based on The Borg Rating of Perceived Exertion (RPE) scale. According to the type of disease and to prevent excessive fatigue, the training pressure was considered at an average level (RPE) of 4-6. Soccer goalkeeping was performed in a three-dimensional environment where one felt himself at the goal of a soccer field. The balls were shot at the goal from different angles, and at each stage, with the success of receiving the balls, the number of throws from different angles increased, and the speed of the throws increased with the improvement of receptions. Every time he was successful, he was applauded by the audience (Figure 1). The training programs for the T group and the T+ VR group were the same and held in a sports gym. To measure motor and cognitive performance, both a pre-test and post-test were administered to all subjects in all three groups.

2.4. Data analysis

The Shapiro-Wilk test was used to determine the normality of the data. The analysis of covariance statistical test used (to eliminate the effect of primary individual differences) and pairwise comparisons of scores using the Bonferroni method. All analyses were conducted using SPSS software version 24, with a significance level of 0.05.

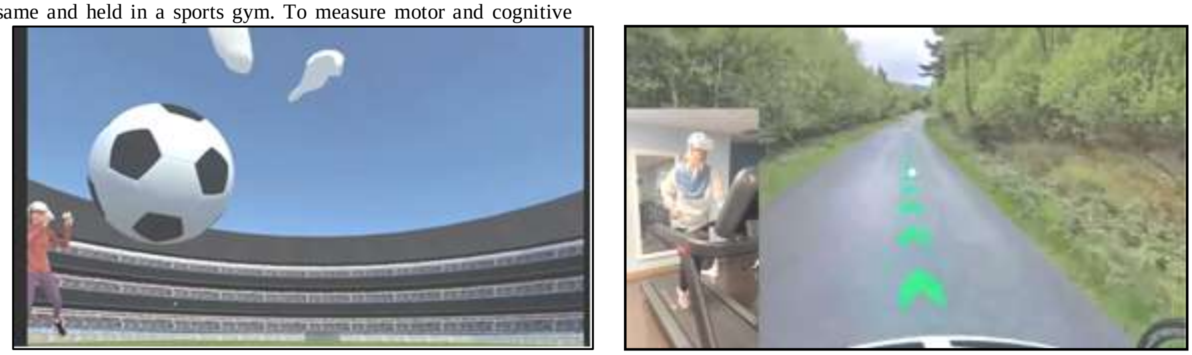

Figure 1: *Walking on a treadmill and practicing football goalkeeping by using VR.*

3. Results

The presuppositions of the covariance statistical test were checked and the results showed that assumption of the linear relationship between dependent variables (post-test results) and covariance variables (pre-test results) was observed. The Shapiro-Wilk and Levin test showed that the data distribution was normal and the variances were homogeneous. Analysis of covariance was used to compare the mean scores of the post-test results of motor performance (walking speed, static balance, dynamic balance, and intensity of fatigue) and cognitive performance (stress, anxiety, depression, problem-solving ability, and mental state).

Between the average scores of the post-test walking speed ($F_{(2,38)} = 134.389$, $P < 0.001$, $\eta^2 = 0.876$), static balance ($F_{(2,38)} = 43.254$, $P < 0.001$, $\eta^2 = 0.743$), dynamic balance ($F_{(2,38)} = 36.410$, $P < 0.001$, $\eta^2 = 0.657$) and intensity of fatigue ($F_{(2,38)} = 177.381$, $P < 0.001$, $\eta^2 = 0.903$) After removing the pre-test results effect, there was a significant difference in the research groups between the mean post-test scores of stress ($F_{(2,37)} = 67.645$, $P < 0.001$, $\eta^2 = 0.785$), anxiety ($F_{(2,37)} = 28.705$, $P < 0.001$, $\eta^2 = 0.608$), depression ($F_{(2,37)} = 219.28$, $P < 0.001$, $\eta^2 = 0.604$), problem-solving ability ($F_{(2,37)} = 71.858$, $P < 0.001$, $\eta^2 = 0.795$), and mental state ($F_{(2,38)} = 6.096$, $P < 0.005$, $\eta^2 = 0.248$) after removing the effect of the pre-test results, there was a significant difference. In other words, the exercise program with and without VR had a significant effect on the stress, anxiety, depression, problem-solving ability, and mental state of women with MS.

In the following, Bonferroni post hoc test was used to determine the difference between the groups in the two sections of motor performance and cognitive performance. The results are reported in Tables 2 and 3. In Table 2, the average scores of the control group in walking speed, dynamic balance, and intensity of fatigue were higher than the average scores of the experimental groups and were lower in static balance. Also, the results showed the average scores of the T+VR group in walking speed. And the intensity of fatigue was lower than the average scores of the T group. But there was no significant difference between them in the average scores of static balance and dynamic balance.

In Table 3, the average scores of the control group in stress, anxiety, and depression were higher, and problem-solving ability and mental state were lower than the average scores of both experimental groups. Also, the results showed that the average scores of the T+VR group were lower in stress, anxiety, depression, and depression and were higher in problem-solving ability than the T Group B. But the average mental state score of both experimental groups had no significant difference.

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Table 2:
Pairwise comparisons of motor performance scores with Bonferroni correction

Variables	Group I	Group J	Average of differences (I-J)	SD	Sig
Walking speed	T+ VR group	T group	-0.73	0.10	0.001
	T+ VR group	Control group	-1.81	0.11	0.001
	T group	Control group	-1.07	0.10	0.001
Static balance	T+ VR group	T group	0.31	0.22	0.182
	T+ VR group A	Control group	2.10	0.24	0.001
	T group	Control group	1.79	0.23	0.001
Dynamic balance	T+ VR group	T group	0.24	0.13	0.093
	T+ VR group	Control group	-0.94	0.14	0.001
	T group	Control group	-1.18	0.14	0.001
Intensity of fatigue	T+ VR group	T group	-0.39	0.06	0.001
	T+ VR group	Control group	-1.23	0.06	0.001
	T group	Control group	-0.84	0.06	0.001

Table 3:
Pairwise comparisons of cognitive performance scores with Bonferroni correction

Variables	Group I	Group J	Average of differences (I-J)	SD	Sig
Stress	T+ VR group	T group	-0.28	0.06	0.001
	T+ VR group	Control group	-0.81	0.07	0.001
	T group	Control group	-0.53	0.06	0.001
Anxiety	T+ VR group	T group	-0.14	0.05	0.014
	T+ VR group A	Control group	-0.44	0.06	0.001
	T group	Control group	-0.30	0.05	0.001
Depression	T+ VR group	T group	-0.22	0.08	0.001
	T+ VR group	Control group	-0.65	0.09	0.001
	T group	Control group	-0.42	0.08	0.001
Problem-solving ability	T+ VR group	T group	1.70	0.28	0.001
	T+ VR group	Control group	3.64	0.30	0.001
	T group	Control group	1.93	0.27	0.001
Mental state	T+ VR group	T group	0.02	0.24	0.932
	T+ VR group	Control group	0.79	0.27	0.001
	T group	Control group	0.77	0.24	0.001

4. Discussion and conclusion

This study aimed to compare the effect of an eight-week exercise program with and without VR on the motor and cognitive performance of women with MS. The study found that an eight-week exercise program, with and without VR, had different effects on the motor (walking and fatigue) and cognitive (stress, anxiety, depression, problem-solving ability, and mental state) performance of women with MS. However, there were no significant differences in static and dynamic balance. In the following, the two issues of motor performance and cognitive performance are discussed separately.

4.1. Motor performance

Consequences of postural control disorders include frequent falls and injuries and lack of coordination in body movements because such individuals have to use many additional movements to maintain their balance (Prosperini et al., 2013). Research has demonstrated that movement exercises can enhance both static and dynamic balance. This study found no significant difference between real and virtual Exercises. Santos Nascimento et al. (2021) confirmed that the effect of using VR in improving balance was equal to or greater than conventional exercises in people with MS. In an overview, Castellano-Aguilera et al. (2022), in a meta-analysis conducted based on little research evidence, found that VR-based treatments are more effective than no intervention or conventional rehabilitation in improving balance and risk of falling in people with MS. Ozkul et al. (2020) also reached similar results showed. Bugnariu-Fung (2010) supported sensory integration in VR and declared that the virtual environment creates sensory conflict due to visual illusion. And the central nervous system can adapt to this conflict by calibrating sensory integration. So, they recommended the use of virtual exercises in balance exercises. In this way, it seems that exercises of static and dynamic balance, in both realistic and virtual form, by activating the neural pathways related to balance in the brain, can improve static and dynamic balance.

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The VR exercise intervention of this study improved the walking of women with MS greater than the training program without VR. The exercises used in this research, walking and soccer goalkeeper training, strengthen the muscles of the trunk and lower extremities. The research results show that MS patients were imbalanced in the core muscles while walking, and the amount of activity is higher on the non-involved side. These muscle patterns represent compensatory mechanisms for controlling posture during dynamic activities such as walking in these people. Meanwhile, to maintain posture control during normal walking, the bilateral activity of the leg and central muscles is required (Ketelhut et al., 2015). Previous studies have shown that even when there were not many changes in walking parameters in people with MS with moderate disability, a significant difference was reported between the central muscles on both sides of the body. Therefore, unbalanced activity in the central muscles should be considered in the rehabilitation of people with MS (Najafi, 2017). Taheri et al. (2022) concluded that the kinematic indicators of walking in the physical training group based on VR improved significantly compared to the control group.

Our results showed that training with VR reduced the intensity of fatigue in the subjects. Fatigue, whether caused by the disease itself or caused by the complications of the disease, hurts the patient's quality of life (Khan et al. 2014). Santos Nascimento et al. (2021) also confirmed that VR training is equal to or more than conventional exercises and reduces fatigue in people with MS. Ozkul et al. (2020) also reached similar results and reminded physical activities have a positive effect on the neuro-muscular system by strengthening the immune system and strengthening the morale of these patients. This issue can delay the fatigue process to a great extent. On the other hand, participants may consume less energy and get less tired during virtual exercises. In MS patients, the feeling of fatigue occurs at the onset of the disease and remains during the mild or severe disease. Therefore, to reduce the feeling of fatigue and its consequences, VR exercises can be used for severe fatigue.

In this study, motor performance was found to improve with both real and virtual exercises. Virtual exercises were found to be more effective than real training in improving walking and reducing fatigue in MS patients. VR training is highly recommended for MS rehabilitation. It allows the nervous system to focus solely on executing movement, without the added burden of safety concerns and fear of falling.

4.2. Cognitive performance

The variables of cognitive performance investigated in this research were: Anxiety, stress, depression, problem-solving, and mental state. This study showed that the exercise program with VR reduced the anxiety of women with MS more than the usual exercise. In general, exercise will reduce anxiety, and this effect is related to the severity of the disease, duration of the disease, and fatigue (Kaveh, 2018. Saladino et al. (2023) consider neuro rehabilitation based on VR in MS patients an effective tool for improving quality of life and mood. Reducing anxiety will improve mental health. The usefulness of VR exercises is an incentive for MS patients to perform these exercises at home as part of their treatment. Creating distractions in VR exercises has positive effects on reducing stress and anxiety. VR game headsets are placed in front of the eyes and block real visual and auditory stimuli, so the patient focuses more on what is happening in the virtual world than on the surrounding environment and events (Patterson et al. 2010). VR involves the patient's conscious attention, and as a result, stress and anxiety are reduced (Sharar et al. 2007).

Virtual reality training was found to be more effective than real training in reducing depression, which is not surprising given the close relationship between anxiety and depression. Studies have shown that cognitive-behavioral approaches are beneficial in the treatment of depression and adaptation in patients with MS (Saadat et al. 2019). On the other hand, Salehi et al. (2021) showed that dual tasks (use of aerobic exercise and VR simultaneously) improve depression in women with MS more than aerobic exercise and VR alone. Anxiety and depression are interrelated and constant anxiety increases the risk of depression. Therefore, anything that reduces perceived anxiety will improve depression. Manoli et al. (2020) stated that the rehabilitation of MS patients using technological innovations is well tolerated by them and can increase commitment and motivation during the rehabilitation process and possible positive effects on the functional and psychological outcomes of MS patients have it. The use of VR in the treatment of depression in people with MS, in addition to the sports aspect, is also considered a psychological intervention because it involves the mind of the patients in a place that is not real, and in this way, for a long time, distracts them from the real world and the problems that due to their illness, it throws them off and helps to improve their depression by exercising in virtual space and enjoying it compared to real exercise. While the release of serotonin hormone in people during sports activities is a proven principle, but probably exercising in a simulated virtual environment increases the release of this hormone. VR technology is easy and non-invasive, and by creating a diversion of thought can be used indefinitely and without the need for repeated expenses, and it does not require much training in addition, its cost is lower than methods such as hypnosis and drug therapy (Ganry et al. 2018).

results showed that the exercise program with VR improved the problem-solving ability of women with MS more than the exercise program without VR. These findings are particularly promising for patients with MS, as they support the feasibility of VR-based exercise training as an effective medium for delivering specific exercise training programs that can be generalized to general aspects of problem-solving and processing. Serino and Pedroli (2016) also show that VR-based sports training leads to improved executive functions related to problem-solving. Therefore, it is recommended to design specific protocols for MS patients to improve cognitive empowerment approaches through virtual space. Interventions based on VR exercises can be used in a wider perspective as non-pharmacological and non-invasive treatments to improve the complications caused by MS, which cause reorganization and improvement of the neurological condition and consequently improve problem-solving through the virtual environment (Repetto et al. 2016). Maggio et al. (2022) also found alignment results. Korthauer et al. (2017) found that performance on the virtual version was associated with better verbal fluency, better response skills, and better mental challenge ability.

In the current research, both methods of physical exercise with and without VR improve the mental state of women with MS equally. The mental state of people with MS is at risk (Kern et al. 2011), so exercise is the most appropriate option to prevent this potential risk (Swank et al. 2013). Grazia Maggio et al. (2022) found that VR training significantly improves cognitive parameters. Sports activities, in any form, improve the mental state of patients with MS. Since it is important to try to improve or reduce the disease of MS, it is suggested to use regular exercises along with social and mental support to improve the mental and physical condition of patients with MS.

This study explored the effects of virtual reality training on female patients with MS. The study found that virtual reality training improved cognitive and motor functions. However, the research was limited due to the lack of access to a community of men with MS, and EMG and EEG measurements may provide better insight into motor and cognitive changes in MS patients.

The research found that sports training with VR technology help to improve the physical and mental condition of MS patients by creating relaxation and controlling stress and anxiety. Because in virtual environments, patients without the need for a therapist at home or work can do rehabilitation training. The visual feedback provided to the patient increases the motivation to perform the exercises. VR is a motivational and effective alternative for the motor and cognitive rehabilitation of MS patients. Depending on the degree of illness and disability, even if it is not possible to do real physical training, each patient can use VR to improve balance and

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walking speed, reduce fatigue, reduce stress, anxiety, and depression, and increase the ability to solve problems and improve mental status. VR training will improve motor and cognitive performance in MS patients and help to deal with the mental and physical effects of the disease by engaging in VR-based sports.

Authors' contributions

Conception and design of the study: SE.R., MH, A. and S. NT; Data collection: SE. R; Data analysis and/or interpretation: SE. R; Drafting of manuscript and/or critical revision: SE.R., MH, A., and S. NT; Approval of final version of manuscript: SE.R., MH, A., and S. NT.

Conflict of interests

The authors declare that there is no conflict of interest.

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