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Effect of Six Weeks Virtual Reality-Based Rehabilitation Exercise and Reflexology on Fatigue Rate of Paralyzed Veterans

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ABSTRACT

Aims One of the consequences of life in today's society is the high prevalence of spinal cord injury, which happens for several reasons. Decreased mobility in these people causes premature fatigue and reduces their quality of life, which leads to diseases. This study aimed to compare the effectiveness of virtual reality-based rehabilitation exercises and reflexology in reducing the fatigue rate of paraplegic veterans.

Instrument & Methods This quasi-experimental study was carried out on paraplegia veterans in Tehran province in 2020. Forty-five active paraplegia veterans with spinal cord injury and a history of regular exercise of with at least 2 years' experience of regular participation in sport activities were randomly classified into three groups: virtual reality, reflexology, and control. The Functional Status Scale is a self-administered questionnaire that was used. Exercise programs were performed for three sessions per week for 30 minutes every other day for six weeks. A post-test was performed after the training sessions. Data were analyzed using SPSS 23 software by ANOVA test.

Findings The mean score of fatigue in the subjects was 45.86±13.57, which was obtained after a pre-test using the fatigue severity scale questionnaire. Findings showed that virtual reality exercises and reflexology had a significant effect on fatigue in paraplegia veterans ($p<0.05$). A significant difference was observed between both experimental and control groups after the intervention ($p<0.05$). The reduction of fatigue was also significant in the massage group ($p<0.05$).

Conclusion There is a reduction in Fatigue rate in Paralyzed Veterans in both massage and virtual reality groups compared to the control group.

Keywords Wheelchair; Rehabilitation; Massage; Spinal Cord Injury; Fatigue

CITATION LINKS

[1] Strength profiles in healthy individuals with ... [2] Model of educational sports development ... [3] Validity of the detection of wheelchair ... [4] Spinal cord injury : a guide ... [5] The biomechanics of spinal ... [6] Partial body weight support with treadmill ... [7] Skeletal muscle adaptations following incomplete ... [8] Update on the pathophysiology and pathology ... [9] Spinal cord injury facts and figures ... [10] Perceived experience of unemployed people ... [11] Epidemiology, physiopathology, and experimental ... [12] Oligodendroglial apoptosis occurs along degenerating ... [13] Epidemiologic features of head and spinal ... [14] Neuropathic pain in spinal cord injury ... [15] Spinal cord injury pain: mechanisms ... [16] Neuropathic pain--A management ... [17] Frequency of phantom pain among ... [18] A systematic review of the prevalence of ... [19] Classication of pain following spinal cord ... [20] Self-regulation in the interpersonal ... [21] Pain Following spinal cord injury ... [22] Assessment of the impact of pain ... [23] Chronic pain after ... [24] Interference due to pain following ... [25] Chronic pain after spinal injury: Interference ... [26] Fatigue and tiredness in people with ... [27] Medication use is associated with fatigue ... [28] Poststroke fatigue: course and its relation ... [29] Two sides of the same coin? On the history ... [30] Fatigue and spinal cord injury ... [31] Physical activity is related to lower levels ... [32] Fatigue level in spinal cord injury AIS D community ... [33] Changes of renal blood flow during organ-associated ... [34] Evaluation of TENS effects in the pain management ... [35] The physiological and biochemical outcomes ... [36] The effect of a virtual reality exercise program ... [37] The validity and reliability of the fatigue ... [38] Effects of virtual reality training using Xbox ... [39] Health-related quality-of-life outcomes: A reflexology ... [40] Effects of slow-stroke back massage on symptom ... [41] Therapeutic massage during chemotherapy ... [42] The effect of reflexology massage on ... [43] Massage therapy for symptom control ... [44] Study of the effects of massagetherapy ... [45] Massage therapy effects on depression ... [46] Effect of foot reflexology on sleep ... [47] Effect of self-administered ... [48] Virtual reality as a distraction ...

Introduction

One of the consequences of life in today's society is the high prevalence of spinal cord injury [1-2], which happens for several reasons such as war, driving, occupational and sports accidents, and natural hazards. Spinal cord injuries are physical injuries that lead to disorders in various body organs and even threaten a person's life. Spinal cord injury led to complete or incomplete muscle paralysis, sensory disturbances, and dysfunction of the autonomic nervous system [3-5]. According to two criteria, spinal cord injury is classified as nerve surface and perfect or incomplete nerve system [6]. In another classification, it can be divided based on impulsive and non-traumatic nerve surfaces [7]. Injuries to the lower back (due to paralysis of the legs) are called paraplegia [3], and injuries to the neck that cause paralysis of the arm muscles, legs, and trunk are called tetraplegia [3]. Studies have shown that spinal cord injury [1] occurs in different countries with an annual incidence of 15 to 40 cases per million people. As mentioned earlier, the causes of these injuries vary from motor vehicle accidents and community violence to recreational activities and workplace injuries [8], and vehicle accidents are the main cause of these injuries and falls. Act of violence such as bullet wounds is the other reason [9]. According to the statistics announced by the Deputy of Health and Martyr Foundation, there are currently about 80,000 spinal disabled people in Iran, of which 2000 are veterans who have suffered casualties during the years of the imposed war. The rest are people who have been injured for various reasons, such as falls from heights, car accidents, and accidents at work and in sports [10]. An estimated 12,000 new cases of paraplegia and quadriplegia occur in the United States each year. Four thousand people die before the hospital, and 1000 people die during hospitalization [5, 11-13]. People with spinal cord injuries, especially the paraplegic group, have many problems, including difficulty in referring to rehabilitation and treatment centers, high costs of healthcare, experiencing various kinds of pain, unfavorable quality of life, and non-participation in exercise activities. In this study, we address the problem of pain, which is considered one of the problems among people with disabilities and can negatively affect their sleep, quality of life, and performance. Statistics show that more than 80% of people with spinal cord injuries experience pain after injury [14]. People with spinal cord injury generally suffer from one or more types of pain, which sometimes this number increases to seven types of pain [15, 16]. Types of pain in these people include neuropathic pain [17], musculoskeletal pain [17, 18], and visceral pain [19]. Neuropathic pain hurts the activities of daily living, and it leads to functional disability due to a lack of mobility [20-22]. It should be noted that pain also directly reduces a person's ability to participate in rehabilitation and return to work [22-25].

In general, fatigue is a feeling of weakness, lack of energy, and loss of strength in a person, in acute and chronic forms [26]. Acute and chronic fatigue is more severe and prolonged [27]. A type of fatigue in people with spinal cord injury does not disappear and reduces the energy of these people to perform their daily activities [28]. Many factors play a role in causing fatigue in these people as long-term hospitalization, side effects of the medicine, medical factors, and lifestyle problems [29]. Many researchers have studied the relationship between fatigue and performance level, its effect on daily life, and improvement the quality of life [30-32]. Hammell *et al.* investigated the relationship between fatigue and depression on the performance of people with spinal cord injury; they found that fatigue and depression harmed the level of performance in the patients due to their insufficient energy [30]. Tawashy *et al.* conducted a similar study and found that people with spinal cord injury were more dependent on others for their daily affairs due to fatigue [31]. Freixes *et al*.studied the relationship between fatigue and the quality of life of people with spinal cord injury. They found that fatigue could affect their quality of life and the treatment process [32].

Reflexology has many physiologic side effects. Sudmeier studied the relationship between the physiological effects in the specific areas of the foot with kidney blood flow by Doppler sonography. It has been found that kidney blood flow was increased with reflexology compared to the group that did not receive reflexology [33]. Increased blood flow to the massaged area improves nutrition and increases the excretion of lactic acid, and this, in turn, leads to energy release and fatigue relief [34]. Also, neural pathways can be mentioned, which are performed by a masseur applying pressure to specific areas of the hand or foot called reflection points (solar plexus, point of the pineal gland, etc.). It is based on the stimulation of these points and affects various organs, glands, and systems of the body by existing neural pathways [35].

In addition, about the mechanism of the effect of virtual reality on reducing fatigue, it was supposed that due to purposeful games, patients' physical fitness increases and reduces perceived fatigue [36].

In general, several methods have been introduced to reduce fatigue in people with spinal cord injury. However, due to the social and economic situation of the patients, specialists are looking for non-invasive, available, and effective methods to improve the fatigue of patients with disabilities. Virtual reality technology is a new method in Iran for sports rehabilitation of people with disabilities, using low-cost techniques such as reflexology massage, which are very easy for the patients to learn. So, This study was aimed to investigate the effect of virtual reality

exercises and reflexology massage on fatigue in paraplegics.

Instrument and Methods

This semi-experimental research was carried out on paraplegia veterans in Tehran province in 2020. This study was conducted to implement research projects at Shahid Beheshti University. Forty-five subjects with paraplegia were purposefully selected based on the inclusion criteria and were classified into three groups, including virtual reality rehabilitation exercises, reflective massage exercises, and control. First, in a meeting with the head of the Veterans and Disabled Board of Tehran Province, the method of research and its objectives were explained and he was asked to provide the researcher with a file related to all veterans and disabled athletes working in clubs related to this institution. A list of qualified people was then prepared and the manager and coach of the clubs in question were contacted. The members of the target clubs were 70 people, 60 of whom were paraplegics, and 45 people were selected by examining their condition and willingness to cooperate with the researcher. After selecting the individuals, the relevant pre-tests were performed and based on that, the individuals were divided into 3 groups of 15 individuals. Determination of sample size has been estimated using G-Power software, the sample size of 15 people for each group with the size of the intervention effect with 95% power was estimated at a significance level of 0.05. The inclusion criteria were spinal cord injury of L4-T12, using a wheelchair for daily work, history of regular exercise for at least the last six months, and a fatigue level of 45-57. The exclusion criteria were history of the disease and injuries during the research period, dissatisfaction with continuing activities and cooperation in research, and absence from training or massage sessions in two consecutive sessions.

The Functional Status Scale is a self-administered questionnaire with 9 items investigating the severity of fatigue in different situations during the past week which are scored on a 7-point Likert scale where 1 indicates strong disagreement and 7 strong agreement, and the final score represents the mean value of the 9 items. This tool is one of the scales useful for the effect of therapeutic interventions on the patients' fatigue severity. The reliability of this tool was confirmed by Azimi *et al.* [37].

To calculate the weight by seca ±50 gr (Ska Engineering Company, Iran), the subjects were weighed sitting in a wheelchair. Then, the weight of the wheelchair and clothes was reduced from the initial weight. Also, to calculate the height of the subjects by seca ±50 gr (Ska Engineering Company, Iran), according to the criteria of the International Society for the Advancement of Kinanthropometry, the sitting height of the subjects was calculated. For this purpose, people sat in a wheelchair, leaning on its fulcrum and keeping their body and head completely straight. The examiner measured the distance from the top of the head to the bottom of the seat with the seca caliper±1mm (Germany), which was recorded as the length of the sitting height. The fatigue severity scale was used to measure the research variable.

This study was approved by the Ethics Committee in Research of Shahid Beheshti University. All ethical principles were considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information. They were free to leave the study whenever they wished, and if desired, the research results would be available to them. At first, after completing the consent form, the subjects completed the fatigue questionnaire under normal conditions and at a specific time. Then, according to the grouping, the individuals entered the control and intervention groups, and after 6 weeks of massage and virtual reality exercises, they completed the questionnaire as a post-test again at a time equal to the time of the pre-test.

In the virtual reality group, we put the Xbox One S (Microsoft, China) Kinect, console, and monitor in space for training. In general, the duration of this program was 6 weeks and 3 sessions per week and the protocol included 10 minutes of warming up, 30 minutes of training, and 10 minutes of cooling [41]. An infrared camera (Microsoft, China) was used as a sensor that detected the player's position and movements and controlled various games by the subject. The game started while the subject was one and a half meters away from the Kinect sensor. The games were selected to involve the upper limb. Games of this protocol included boxing, table tennis, archery, golf, volleyball, and fencing [38].

In the second experimental group, massage was applied for 6 weeks and 3 sessions per week and the duration of each reflective massage session was 30 minutes. The first 10 minutes of each session was devoted to relaxation techniques. These techniques included back and forth movements of the massager palm in the inner and outer area of the subject's hand. For the next 15 minutes, a reflexology massage was performed on areas of the palm associated with fatigue.

Descriptive statistical methods were used for data sorting, and the One-Way ANOVA test was used for data analysis using SPSS 23 software. Data distribution was assessed using the Shapirovilk test.

Findings

The demographic characteristics of the subjects are shown in Table 1.

Exploratory data analysis was performed to identify the properties of dependent variables and to identify the necessary assumptions for using the appropriate statistical test. According to the Shapiro-Wilk test,

the fatigue variable data had a normal distribution at the significance level of p≤0.05. Data were analyzed using parametric tests. The intragroup changes were assessed using a one-way analysis of variance test. Considering the significance of the results, the Tukey post hoc test was used to determine the extra group changes.

The results of the one-way analysis of variance for the fatigue-related variable showed that the decrease in fatigue severity in both virtual reality and massage groups was statistically significant (F=9.49, p≤0.001)

There was no significant difference in the effect of fatigue between these three groups.

The results of the Tukey post hoc test also showed that there was no significant difference in reducing fatigue between the massage group (28.9±20.65) and virtual reality (27.8±93.97) (p=0.99). In contrast, there was a significant difference between the massage and control groups (44.60±16.05) (p=0.002) and between the virtual reality and control groups (p=0.001). According to pre-test and post-test means, it was seen that the changes in reducing fatigue were greater in the massage group.

Table 1) Demographic characteristics of the subjects in the three groups

Variable	Virtual reality	Massage	Control
Height of the upper body (cm)	69.73±5.31	71.46±5.55	70.00±6.56
Weight (kg)	77.00±10.10	71.13±7.71	72.66±5.50
Age (year)	55.06±3.69	54.13±4.95	53.80±5.01

Discussion

This study aimed to investigate the effect of reflexology massage and virtual reality on reducing fatigue of paraplegia veterans. The results showed that the interventions greatly affected reducing fatigue in the veterans, and the massage was greater in this reduction. Reflexology has many physiological side effects, in which several studies have been performed in this area. In this area, Sudmeier studied the related physiologic effects in the specific areas of the foot and blood flow to the relevant area (which in this study was a kidney) by Doppler sonography, and fonshipound that kidney blood flow was increased compared to the group that did not receive reflexology [33]. Increased blood flow to the massaged area improves nutrition and increases the excretion of waste products, including lactic acid, leading to energy release and fatigue relief [34]. Also, neural pathways can be mentioned, which a masseur performs by applying pressure to specific areas (solar plexus, point of the pineal gland, etc.) of the hand or foot called reflection points. Its basis is stimulation of these points, which are sent to the body's various organs, glands, and systems by existing neural pathways [35]. The reason for using hand reflexology massage in people with paraplegia was that in these types of disabilities, the nerve pathways of the lower limbs are usually not completely healthy, and it was better to replace hand reflexology with foot reflexology.

There has not been enough research on reflexology massage in people with spinal cord injuries in the lower back. For this reason, the effects of this type of massage have been studied on reducing fatigue in similar groups.

The findings were consistent with the results of the study by Wiatt *et al.* Their findings also showed that reflexology massage effectively reduces pain, anxiety, and nausea and reduces fatigue in people with breast cancer [39]. The findings of Miladinia [40] and Robinson *et al.* [41] on patients undergoing chemotherapy revealed that reflexology massage reduced pain factors, nausea, and fatigue.

Rigi *et al.* studied the effects of reflexology on the fatigue of women with multiple sclerosis. This study was performed for four weeks and three 30-minute sessions per week on the sunspots, and the results showed a decrease in the subjects' fatigue after receiving the message [42].

There were a few studies to studies inconsistent with this study, including Cassileth *et al.* [43] on the effect of massage on fatigue of cancer patients. The research showed the lack of effect of massage on reducing fatigue in patients immediately after massage. The reason for the inconsistency of the findings of Cassileth *et al.* with the results of this study was the side effects of chemotherapy that lead to an increase in abnormal fatigue in the patients and investigating the instant evaluation of the effect of massage. In contrast, the present study investigated the effect of massage on fatigue after five weeks.

In another study conducted by Abbasi *et al.,* The effect of massage on labor fatigue was investigated. The results of this study also showed the effectiveness of massage in reducing the severity of fatigue [44].

Field *et al.* Also studied the effect of massage on chronic fatigue, the results of which showed no immediate effect of massage on fatigue, but in the next phase, which examined its long-term effect and the results showed that 5 weeks of massage reduced fatigue in People had been [45].

In another study, Sayari *et al.* Examined the effect of reflexology massage on sleep quality and fatigue severity in patients with acute myocardial infarction. The results of this study showed that twenty minutes of reflexology massage reduced the severity of fatigue in these individuals [46]. In a study, Song *et al.* Examined the effect of self-reflexology massage on reducing the severity of fatigue in healthy people, the results of which showed the effectiveness of this massage [47].

Few studies have been conducted on the effect of the virtual reality system on reducing fatigue. The findings of Cho & Shang [36] are in accordance with this study. They examined the effect of the virtual reality system on fitness, body composition, and

fatigue in hemodialysis patients. Their research showed that the exercises using the virtual reality system positively reduced fatigue [39]. Regarding the effect of virtual reality on reducing fatigue, it was soused that the perceived fatigue has been reduced due to improving the level of physical fitness in the patients [37].

There were a few studies in this area, although none of them were performed in the paraplegic spinal cord injury group. For example, Schneider *et al.* [48] examined the effect of a virtual reality system on reducing fatigue in women with breast cancer. They found that the highest and lowest level of fatigue occurred two days and immediately after chemotherapy, respectively, when patients were using a virtual reality system exercise. There were no significant changes in any of the criteria for fatigue or anxiety two days later in exercises based on virtual reality. Still, virtual reality-based rehabilitation exercises tended to achieve lower fatigue scores [48].

Conclusion

There is a reduction in the Fatigue rate in Paralyzed Veterans in both massage and virtual reality groups compared to the control group. Therefore, based on the findings of this study, it is suggested to provide virtual reality systems to disabled persons in the sports clubs and sanatoriums where people with disabilities practice and live, as well as rooms, should be equipped for massage so that it can help improve the quality of life of people with disabilities while reducing their pain and fatigue.

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Ethical Permissions: It is worth mentioning that after the approval of the proposal in the group, the code of ethics was received from the ethics committee in the research of Shahid Beheshti University with the number IR.SBU.REC.1400.072. This study was also registered in the Iranian Clinical Trials Registration Center with the code IRCT20210924052562N1.

Conflicts of Interests: This article is extracted from a master's thesis at Shahid Beheshti University.

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