The Effect of Exercise Training and Virtual Reality on Selected Psychomotor Variables in Armed Forces Personnel dealing with Post-Traumatic Stress Disorder (PTSD)

Abstract

Aims The purpose of this research was to assess the effect of exercise and exergame interventions on the psychomotor aspects of armed forces personnel diagnosed with post-traumatic stress disorder.

Instruments & methods the study utilized a quasi-experimental design involving pre-test and post-test measurements with a control group. Initially, 60 men of the Armed Forces of the Islamic Republic of Iran with PTSD diagnosis were purposefully selected and then randomly assigned to three groups: Pilates training, exergame intervention, and control (20 individuals in each group). The exercise and exergame sessions were conducted over 24 sessions (3 one-hour sessions per week) for the experimental groups, while the control group continued with their regular activities and treatment programs. The berg Functional Balance and Motor Coordination (Tandem gait) along with the Quality-of-Life Questionnaire (SF-36) were administered at both pre-test and post-test stages. Statistical analysis carried out using SPSS-25 software, involved multivariate analysis of variance and Bonferroni's post hoc test, with a significance level set at 0.05 for all tests.

Findings The results demonstrated a significant positive effect of exercise and exergame interventions on the psychomotor components of the participants. Further examination revealed that Pilates exercises were more effective than exergame interventions in enhancing both quality of life and motor coordination, with no difference identified in functional balance between two groups.

Conclusion Given the high demands and sensitivities within Armed Forces organizations, it is recommended that consideration be given to establishing specialized facilities where personnel can benefit from tailored sports exercises and exergame interventions.

Keywords Post-traumatic stress, Pilates, virtual reality, functional balance, quality of life, motor coordination.

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Introduction:

Post-Traumatic Stress Disorder (PTSD), formerly known as "war-related psychiatric disorders," is a significant and incapacitating mental health condition that arises following exposure to a traumatic event or the recollection and re-experiencing of such an event (1). Following the onset of post-traumatic stress disorder (PTSD), individuals exhibit pronounced clinical symptoms that are linked to significant adverse effects on both mental and physical health, as well as a substantial decline in overall quality of life (2). Recent studies have pointed to an increased risk of PTSD among military personnel dealing with daily high-stress situations, particularly those facing wartime conditions (3, 4). Platania and colleagues demonstrated in their study that the risk of exposure to PTSD increases among military personnel who encounter severe stress-inducing events (5).

The prevalence of post-traumatic stress disorder varies significantly worldwide (6, 7). The current estimate in the United States suggests that 6 to 8 percent of adults aged 18 or older live with this disorder, with active U.S. military personnel facing rates 2 to 3 times higher (3, 7). In Iran, there is no exact statistics of those suffering from this disorder among the warriors returning from the war or other military personnel, but some studies have mentioned its prevalence between 20 and 30 percent (8).

Multiple studies demonstrate that the persistence of post-traumatic stress disorder leads to several physiological and biological consequences, including reduced sensory function (vision, vestibular, proprioception), motor function (strength, coordination, endurance) and integration (response time, the ability to do several tasks) which can lead to accelerated decline in performance and as a result impaired functional balance, motor coordination and muscle weakness at the end of life (9). Motor coordination and function are closely interconnected and play a key role in physical-motor fitness, thereby influencing various aspects of quality of life (10). Quality of life personal beliefs, and social interaction (11). Post-traumatic stress disorder directly influences all aspects of quality of life by reducing physical, psychological, and social functioning, potentially hindering individuals from conducting daily activities across diverse life domains (12). Encompasses various dimensions such as physical health, mental well-being,

Recognizing the significance of enhancing psychomotor components in individuals with PTSD, particularly within the military, there exists contradictory findings regarding the effectiveness of different treatment protocols (7, 13). Non-pharmacological approaches, such as regular participation in physical activity programs, represent one avenue to promote both physical and cognitive health (14, 15).

Moreover, the benefits of physical activity extend to inactive elderly women, with meditation, yoga, rhythmic movements, and aerobics proven to decrease depression levels and elevate quality of life (16). Pilates is an emerging mind-body exercise emphasizing precise control, posture, and breathing. With its focus on body-mind coordination and attention to balance and posture control, Pilates presents a valuable intervention for enhancing psychomotor components in individuals (17).

Various studies have demonstrated the effectiveness of these exercises in improving postural control, muscular strength, motor coordination, and quality of life factors. For instance, an improvement in the quality of life of patients with spondylolysis was reported after 8 weeks of Pilates training (18). Additionally, researchers have noted enhancements in balance and motor coordination, along with reductions in anxiety, depression, and fatigue, as well as an increase in quality of life and vitality following 6 weeks of Pilates exercises (19).

On the other hand, in recent years, the use of virtual reality exercises (exergame) for the rehabilitation of patients is one of the scientific fields that has attracted the attention of researchers (20). Exergame is a type of virtual reality and a new technology that allows a person to interact with a simulated computer environment. In this method, a person can perform the tasks asked of him in the virtual environment in a real environment and evaluate and correct his performance through instant feedback received from the virtual environment and also predict the events of the environment. And react appropriately to them. Exergame has become a cheap and reliable program to implement and improve health programs, balance and control neuromuscular coordination (21). Castelli et al, supported the positive effects of video game rehabilitation on balance and mobility and psychological factors (stress, anxiety) of people with MS (22). However, what has not been

In Press

addressed so far is the effects of these interventions on soldiers suffering from PTSD, and the results of this research, in addition to providing evidence in the field of improving the quality of life and reducing the problems of these people, can be used as an effective program and in At the same time, it is pleasant to be introduced along with other treatment and rehabilitation protocols.
The integration of Pilates and exergame exercises, characterized by their varied and targeted movements, presents a promising alternative for enhancing physical activity participation within the community, particularly among military personnel. Given the limited historical context regarding the efficacy of Pilates and exergame exercises on psychomotor components, there is a pressing need to advocate for these modalities and establish a framework to promote their utilization, particularly among armed forces personnel. Thus, this study seeks to explore the effects of Pilates and Exergame exercise interventions on the psychomotor components of military personnel diagnosed with post-traumatic stress disorder (PTSD).

Material and Methods

The research approach utilized a practical, semi-experimental method, implementing a pre-test-post-test design with two experimental groups and a control group.

1. Statistical population and sample size

The study focused on a statistical sample of male armed forces personnel with post-traumatic stress disorder, who were seeking treatment from established psychological centers. The sample size was determined using the formula $n = \frac{SX^2 \times Z\propto^2/2}{D^2}$, with 20 individuals in each group, taking into account a Type one error of 0.05 (23). A total of 60 participants were purposefully chosen from specialist centers in Yazd, meeting specific criteria and willingly participating in the study. Inclusion criteria encompassed male armed forces employees aged 30-55 years, devoid of recent lower limb fractures, not reliant on walking aids, and without significant visual, hearing, or cognitive impairments. Additionally, participants had to be free from other neurological diseases, refrain from concurrent psychological interventions, and undergo verification through a demographic information form and expert assessment. Exclusion criteria consisted of non-participation during evaluation or intervention sessions, missing more than two consecutive sessions, breaching entry criteria, such as irregular sleep patterns and substance use, and lack of participant consent. These criteria were closely monitored by collecting reports from the participants to ensure their continued involvement in the project.

2. Data Collection Tools

1. Personal Information Form: The personal information form developed by the researcher includes inquiries about age, weight, height, gender, education level, disclosure of any physical and cognitive ailments, and more.

2. Informed Consent Form for Research Participation: This consent form comprehensively outlines the research's aims and characteristics, assuring participants that the experiment will not inflect any specific physical or psychological harm. It also emphasizes their right to withdraw from the study at any stage while ensuring the confidentiality of their information.

3. Quality of Life Questionnaire: To gauge the quality of life, the researchers utilized the internationally recognized SF-36 questionnaire. The scale comprises 36 items encompassing both physical and psychological domains, with eight subscales measuring various aspects such as physical functioning, limitations due to physical issues, bodily pain, general health, energy levels, social functioning, mental well-being, and more(24). The reliability and validity of the SF-36 in Iran were initially examined by Montazeri et al, yielding subscale reliability coefficients ranging from 0.77 to 0.95 (25).

4. Functional Balance: Functional balance was evaluated using the balance scale test, deemed as a gold standard for appraising functional balance. This clinical assessment comprises 14 balance tests, assessing various actions like transitioning from sitting to standing, standing without support, standing with eyes closed, and other balance-related activities. Each test is scored from 0 to 4, resulting in a maximum total score of 56 (26). The validity and reliability of this test have been confirmed within the Iranian community, by salavati (27).

5. Motor Coordination: The assessment of motor coordination involved employing the Tandem Gait Coordination Test, which assesses the subject's ability to perform a straight-line walk heel to toe for 15 steps, with unrestricted hand movements alongside body coordination. The test has a

In Press

maximum score of 15, and if the participant deviates from the designated path before completing 15 steps, the test stops, and the number of steps taken is recorded as the participant's score. The test's validity and reliability have been confirmed in local studies (28).

3. Implementation method

The research was conducted following ethical approval from the Ethics Committee of the of Sport Sciences research Institute. The research was done in 2023.

The participants were randomly divided into three categories: one group performed Pilates exercises (comprising 20 individuals), another group engaged in Exergame virtual reality interventions (also with 20 individuals), and finally, a control group (consisting of 20 individuals). The two experimental groups undertook their respective interventions over an 8-week period, with three one-hour sessions each week, while the control group continued with their regular daily activities and treatment methods.

According to the protocol of Pilates exercises (29), these exercises were performed in four stages; The first part of exercises on the mat (first 2 weeks); The second part of exercises using an aerobic ball (second 2 weeks); The third part of exercises using light weights and bands (the third 2 weeks) and the fourth part of combined exercises from the previous three parts (the last two weeks). The movements started from simple and then their intensity and complexity increased. In contrast, the virtual reality group utilizes specialized software for Xbox devices, employing sports-based activities such as boxing, table tennis, football, golf, and American football. Subjects are trained in the virtual reality exercises before the intervention, with each session including warm-up, intervention activities, and a cooldown period for a duration of eight weeks.

Descriptive statistics such as mean, standard deviation, and various measures of central tendency were utilized to statistically characterize the data procured from the study. Multivariate analysis of variance was separately employed to assess the comparative effectiveness of Pilates and virtual reality exercises on psychological (specifically, quality of life) and motor (functional balance and motor coordination) domains. Additionally, the Bonferroni post hoc test was conducted to pinpoint specific differences. The statistical analysis was carried out utilizing SPSS software version 25, at a significance level of 0.05. Before analyzing the data using Multivariate covariance analysis, its assumptions were checked. The results showed that based on the Shapiro-Wilk and Kolmogorov-Smirnov tests, the statistical assumption of normal distribution for the quality-of-life variable as the psychological component and balance and movement coordination as the motor components is established in both pre- and post-test stages ($p<0.05$). Assuming homogeneity of variances through Levene's test for quality of life ($P=0.754$, $F=0.284$), balance ($P=0.350$, $F=3.544$) and motor coordination ($P=0.902$, $F=10.30$) was confirmed. The assumption of homogeneity of covariance matrices was checked and confirmed through the M'box test ($P=0.069$, $F=1.40$, Box's $M=48.36$). Based on this, the conditions for using the statistical test of multivariate covariance analysis were met.

Findings

The values related to the demographic variables of the participants can be seen in Table 1.

Table 1: characteristics of research participants by group Descriptive values related to the demographic

groups / statistics	Number	Age (mean ± standard deviation)	height (mean ± standard deviation)	Weight (mean ± standard deviation)	Military service record (mean ± standard deviation)	History of disorder (mean ± standard deviation)
Sport training (PL)	20	45.11±5.37	1.75±0.06	78.57±7.30	15.10±4.20	1.50±0.40
Exergame training (EG)	20	44.07±5.46	1.74±0.05	76.62±5.60	14.70±4.80	1.20±0.60
Control (CO)	20	43.32±5.09	1.76±0.04	78.79±6.32	13.30±5.10	1.60±0.30

The values related to the mean and standard deviation of the variables measured from the subjects of this research in the two test, separated by experimental groups, can be seen in the table below-test and post-stages of pre.

able 2: test stages-test and post-by group in the preof the subjects Mean values, standard deviation of the measured variables

In Press

variables	stages / groups	Sport training (mean ± standard deviation)	Exergame (mean ± standard deviation)	Control (mean ± standard deviation)
Quality of life	Pre test	67.10±7.97	66.55±8.71	66.05±8.91
	Post test	76.85±9.02	36.55±8.61	66.85±8.48
Balance	Pre test	28.20±9.43	29.10±9.02	27.90±9.78
	Post test	36.10±10.16	40.85±6.89	28.65±10.43
Motor coordination	Pre test	7.85±2.92	8.15±2.71	8.30±2.20
	Post test	13.30±1.83	12.30±1.78	8.75±1.97

The results of the Wilks's lambda test from the set of -multivariate tests showed that there was a significant difference between the experimental group of exercise training, exergame and control at least in the quality-of-life variable ($p<0.01$, $F=14.201$). The value of Wilks's lambda test for functional balance and motor coordination also confirmed a significant difference between the groups ($p>0.01$, $F=23.770$). According to the eta square, it can be stated that 76, 65 and 53% of the difference in quality-of-life scores, functional balance and movement coordination is the result of the difference in training methods ($p<0.01$). The findings of the multivariate covariance test can be seen in Table 3.

Table 3:The results of the multivariate covariance test to determine the difference in the mean score of the variables in the test phases-test and post-pre

variables	Source of changes	sum of squares	DF	meanof squares	F	P-value	Eta square	Eta power
Quality of life	test-pre	3208.64	1	3208.64	175.82	<0.01	0.765	1.00
	group	434.36	2	434.36	23.80	<0.01	0.469	1.00
	error	985.43	55	17.91				
Balance	test-pre	3203.08	1	3203.08	103.92	<0.01	0.654	1.00
	group	1302.84	2	651.42	21.13	<0.01	0.435	1.00
	error	1695.10	55	30.82				
Motor coordination	test-pre	105.28	1	105.28	62.78	<0.01	0.533	1.00
	group	247.50	2	123.75	73.79	<0.01	0.729	1.00
	error	92.23	55	1.67				

Bonferroni's post hoc test was used to determine the difference between the three groups, the resultsof which can be seen in Table 4.

able 4: between the three Bonferroni's post hoc test results in order to pairwise compare the scores of the evaluated variables search groups

variables	groups		Difference of means	standard error	P-value
Quality of life	Sport training	Exergame	6.85	1.36	<0.01*
	Sport training	control	9.08	1.37	<0.01
	Exergame	control	2.22	1.35	0.319
Balance	Sport training	Exergame	-3.97	1.75	0.084
	Sport training	control	7.30	1.76	<0.01*

	Exergame	control	11.27	1.75	<0.01*
Motor coordination	Sport training	Exergame	1.15	0.41	<0.05*
	Sport training	control	4.78	0.41	<0.01*
	Exergame	control	3.62	0.41	<0.01*

Based on the results of the table above, it was determined that Pilates trainings significantly improved quality of life scores more than exergame intervention. There was no significant difference between the control and exergame groups. The group of virtual reality intervention (exergame) and Pilates had a significant difference compared to the control group, but no significant difference was observed between these two training methods. In the motor coordination variable, there was a significant difference between the two training methods of Exergame and Pilates and between these two training methods and the control group.

Discussion

The objective of this study was to explore the impact of Pilates and virtual reality exercises on the various aspects of quality of life, functional balance, and motor coordination among military personnel diagnosed with post-traumatic stress disorder (PTSD). The findings showed that both types of activities significantly improved participants' quality of life. Specifically, the positive effects of Pilates on quality-of-life matched earlier research by Jamali and colleagues (18), Akbaş (19), and Jalali et al. (30). However, these results contrasted with those reported by Hasani et al. (31). Such differences might stem from variations in exercise types, intensities, intervention durations, and the lifestyles of the participants. Pilates not only boosts physical and mental well-being but also helps reduce depression, anxiety, and sleep issues. This, in turn, enhances individuals' abilities to perform daily tasks, make better decisions, feel more satisfied, and engage more effectively in their activities, leading to an overall better quality of life (19, 32). Regarding the results of exergame on quality-of-life components, it's worth noting that this is a newer form of exercise that leverages computer technology and extensive data processing. Recent studies have been investigating how effective these activities are for various physical and mental health functions. Virtual reality games, in particular, offer a wide range of options and create interactive experiences that can improve patients' mental health while also enhancing their physiological well-being. A systematic review by Chuang et al. highlighted a significant positive impact of virtual reality interventions on the mental health of those with psychological disorders (21). The benefits of exergame can be explained by its ability to stimulate the release of dopamine, serotonin, and endorphins, which contribute to feelings of happiness and well-being (20, 21). While the study found that both Pilates and exergame positively influenced the quality of life for military personnel with PTSD, Pilates proved to be more effective than exergame. This raises an important question: Should individuals concentrate on aerobic exercises to improve their capabilities, or would participating in structured sports be more beneficial? This topic certainly warrants further investigation.

The current study found that both Pilates exercises and virtual reality significantly enhanced functional balance and motor coordination in military personnel dealing with post-traumatic stress disorder (PTSD). This positive effect on balance is consistent with previous research. For instance, Yazdani and colleagues showed that Pilates exercises effectively improved postural control in older women who had experienced falls (33). Similarly, Mohammadi Arani et al. conducted an 8-week Pilates program for elderly women, revealing significant improvements in both static and dynamic balance (34). The benefits of Pilates can be attributed to its ability to reduce visceral fat, which may help alleviate pain across different body areas and prevent injuries related to overuse or excessive strain on muscles. Additionally, improved balance can result from various neural adaptations that occur with training. These adaptations include using more efficient neural units, reorganizing the sensory-motor cortex, enhancing the effectiveness of synaptic connections, increasing overall nervous system activation, reducing inhibitory responses, and improving the transmission of impulses between neural pathways. All these factors contribute to better sensory processing and coordination (17, 30, 31). The body operates as a kinetic chain, where every system and muscle group play an essential role. In this framework, strength, core stability, and balance are all interconnected (29, 35). Also, research evidence shows that exergame interventions, as an attractive and enjoyable method, can increase the level of interaction and participation and adherence to the rehabilitation process in people (20, 21). For instance, Memon and colleagues found that virtual reality games positively affected balance and lower limb function in children with

In Press

Down syndrome(36). Similarly, Taheri and his team reported that an eight-week program of virtual reality-based physical training significantly improved walking mechanics, muscle strength, and balance in women with multiple sclerosis (37). One reason virtual reality games are seen as beneficial could be their ability to enhance blood flow in specific brain areas, like the superior temporal gyrus, which is important for balance. These virtual reality programs stimulate these regions, leading to changes in the brain's structure and function (20, 21). Virtual reality offers several advantages, including the opportunity for repetitive practice in a fun and motivating environment, reduced fear of failure, the introduction of new games in each therapy session that gradually increase in complexity, and quick sensory feedback during gameplay. These features help create a training experience that closely resembles real-life situations (20, 21). This study highlights how such interventions can positively impact functional balance, motor coordination, and overall quality of life for military personnel dealing with PTSD.

However, there are some limitations to this study. The sample included only male military personnel with PTSD, so we should be cautious about applying these results to other groups. Additionally, the research relied on convenience sampling and did not include follow-up assessments of the interventions. Given the limited research on PTSD in military settings, future studies should aim to address these limitations and explore additional psychological and motor factors.

Conclusion

The study's results show that exercise and virtual reality training significantly improve the psychomotor skills of military personnel suffering from post-traumatic stress disorder (PTSD). Therefore, it is suggested that these training programs be incorporated alongside other activities for military members, especially for those dealing with PTSD.

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