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The effect of whole body Electromyostimulation exercises on improving static balance and self-efficacy in the elderly

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ABSTRACT

The primary aim of this research was to investigate the effect of electrical muscle stimulation (EMS) on the enhancement of static balance and self-efficacy in elderly individuals. This quasi-experimental study employed a pre-test and post-test design, encompassing two groups: an experimental group and a control group. The study involved elderly women aged between 65 and 70 years from Mashhad. Twenty participants from this age group were voluntarily and selectively recruited in accordance with the objectives of the study. They were then randomly divided into two groups: one receiving EMS training and the other serving as a control group. Data collection involved administering the Elderly Self-Efficacy Questionnaire and conducting static balance tests, including the use of a Biodex device and the Sharpened Romberg test, at both the pre-test and post-test phases. The EMS training lasted for 8 weeks, with two 20-minute sessions per week, and was divided into three phases: adaptation (2 weeks), initial exercises (2 weeks), and main exercises (4 weeks). The control group did not receive any intervention during this period. Post-test evaluations were conducted for both groups, similar to the pre-test. The Multivariate Analysis of Covariance (MANCOVA) was used to analyze changes both within and between groups, employing a significance threshold of less than five percent, with the analysis conducted using SPSS software, version 24. The findings indicated that EMS exercises significantly improved static balance in the elderly ($p < 0.05$). However, these exercises did not demonstrate a significant effect on the elderly's self-efficacy ($p < 0.05$). Given these results, coaches and caregivers are encouraged to consider electrical muscle stimulation as a viable, safe method to augment balance and independent mobility in elderly women.

Keywords: *Electrical Muscle Stimulation, Balance Performance, Self-Efficacy, Elderly Women.*

1. Introduction

The aging process is an inescapable phase of human life (1). As per the latest data from the Statistical Center of Iran in 2016, the elderly demographic represents approximately 9% of the nation's total populace (2). Projections suggest that in about 30 years, nearly 30% of Iran's population and 20% of the global population will be elderly. With the escalating numbers of the elderly, coupled with societal advancements and an increase in the life expectancy index, recognizing and addressing the challenges of old age is crucial for enhancing their health status (3). A critical concern in aging is balance. The efficiency of mechanisms responsible for maintaining balance and mobility tends to decline due to alterations in various body systems, including the visual, vestibular, proprioceptive, and notably, the nervous systems. This decline escalates the risk of falls, which can have substantial physical, psychological, and economic repercussions for individuals and society, and may even result in fatalities. Numerous studies have investigated the causes of falls among the elderly (4). Their findings categorize these causes into external or environmental factors (such as inadequate lighting or unreliable surfaces) and internal factors (like lower limb muscle weakness, diminished vibration sensation, slower motor responses, and balance issues). Particularly, the decrease in lower limb muscle strength, and consequently balance, is recognized as a key factor in preventing or reducing falls in the elderly *(*5*)*. Additionally, the elderly often face psychological challenges, including diminished self-efficacy and well-being. Psychological well-being transcends mere pleasure and encompasses the pursuit of excellence and the realization of one's potential. The senior years, marked by a decline in physiological capacities and motor functions, can result from deteriorating neuromuscular systems, psychological factors, environmental conditions, lifestyle choices, and other variables *(*6 ,7*)*.

In recent years, advancements in science and technology, along with a deeper understanding of modern sports methodologies like Electrical Muscle Stimulation (EMS), have led to the development of high-intensity training programs for the elderly. These programs successfully enhance strength and endurance. The positive impact of localized electromyostimulation on neuromuscular parameters, previously observed in athletes, is well-documented. Several researchers have demonstrated EMS's effectiveness in boosting muscular strength and dynamic balance in postmenopausal women, suggesting its potential in improving isometric strength and dynamic balance (8). Nonetheless, in gerontology, research on the impact of electrical muscle stimulation on strength and balance is limited. A growing number of elderly individuals are unable to engage in regular physical activities(9). Some studies advocate for the use of EMS as a high-intensity exercise to ameliorate the physical condition of elderly women (10). EMS appears to enhance muscle mass and functional characteristics of limb muscles, making it a potentially valuable tool for treating patients with sarcopenia and muscle atrophy (9). Research has highlighted significant improvements in positional muscle electrical stimulation and static posturography feedback in elderly patients with balance disorders after one month. Investigations into the positive effects of electromyostimulation on upper muscle strength and elbow joint extensor performance have reported notable differences (11). In light of these considerations and a review of studies on the impact of electrical muscle stimulation on kinematic and psychological indices, and given the scarcity of research in the elderly population, this study seeks to address a fundamental question: Can electrical muscle stimulation improve static balance and self-efficacy in the elderly?

2. Methods and Materials

2.1. Study Design and Participants

The current study adopts a quasi-experimental design, incorporating a pre-test and post-test structure across two groups: a training group and a control group. In terms of its purpose, the research is applied. The statistical population comprised elderly women aged between 65 and 70 years, residing in Mashhad, who were ambulatory and living independently. The study participants included 20 elderly women within this age range, voluntarily selected from Mashhad's elderly female population in alignment with the study's objectives. Following their selection, they were randomly allocated into two groups: one for electrical muscle stimulation training (comprising 10 individuals) and the control group (also 10 individuals). Prior to the intervention, participants completed a static balance test and a self-efficacy questionnaire as part of the pre-test. Subsequently, the training group underwent electrical muscle stimulation sessions twice weekly, each lasting 20 minutes, over a period of 8 weeks. The control group did not receive any intervention during this phase. Both groups were subjected to the post-test, conducted similarly to the pre-test.

Health Nexus
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2.2. Measures and Tools

Static Balance Measurement: The assessment of static balance involved the use of the Biodex balance system and the Romberg test. The Biodex device measures body oscillations in both stable (static) and unstable (dynamic) states. It features a platform adjustable for various levels of stability and instability. The device quantifies balance performance through two indices: deviations and oscillations of the center of gravity (referring to deviations and oscillations of an imaginary line of gravity passing through the center of pressure on the device's surface). Reduced oscillations signify improved performance (as illustrated in Figure 1 and Figure 2).

Figure 1

Biodex Balance Measurement Device

Figure 2

Method of Performing the Static Balance Test

Additionally, the **Sharpened Romberg Test** was employed for static balance assessment. In this test, the participant stands barefoot on a level surface, positioning the dominant foot in front of the non-dominant one, so the heel of the front foot touches the toes of the back foot. The arms are crossed over the chest, with each hand resting on the opposing shoulder. The test is conducted with the eyes closed. The duration for which the individual can maintain this stance with their eyes closed is recorded as their score. The reliability of the Sharpened Romberg Test has been documented at 0.90 with eyes open and 0.76 with eyes closed (12).

Health Nexus
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The Elderly Self-Efficacy Questionnaire: Developed in 2010 by Roberts, Dolansky, and Weber, this questionnaire assesses the confidence and belief of the elderly in their capability to perform movement-based tasks. Comprising 18 questions, it includes 11 questions focused on self-care and seven on mobility level in the elderly. The responses are scored on a 10-point Likert scale, where 1 represents 'not confident at all' and 10 signifies 'completely confident'. The scale's minimum score is 18, and the maximum is 180, with higher scores indicating greater self-efficacy. In the 2010 study by Roberts, Dolansky, and Weber, the internal consistency of this tool was reported as 0.96, with Cronbach's alpha coefficients for the subscales of self-care, active activities, and overall self-efficacy at 0.96, 0.94, and 0.97, respectively(13). The validity and reliability of this questionnaire in Iran were confirmed by Golmohammadi and colleagues in 2015 (14).

2.3. Interventions

Electrical Muscle Stimulation Protocol: The electrical muscle stimulation regimen spanned 8 weeks, consisting of two 20-minute sessions per week, amounting to 16 sessions or 320 minutes of electrical stimulation over two months. This training was segmented into three phases: adaptation (2 weeks), initial exercises (2 weeks), and main exercises (4 weeks). Each phase's training details, including stimulation duration, intensity, depth, electrical resistance, and targeted muscle groups, are specified (15).

Figure 3 illustrates the electrical muscle stimulation device. The training phases are outlined below:

- Adaptation Training Protocol: Stimulation frequency: 35 HZ; Impulse duration: 10 s; mpulse break: 5 s; Amperage: 15;

-Muscle depth: Abdominal, Lumbar, Quadriceps, Hamstring, Gluteus at 200; Duration: 20 minutes

Initial Training Protocol: Stimulation frequency: 55 HZ -Impulse durations:25 s -Impulse break:5 s -Amper:25 -Depth muscle- Abdominal:300-Lumbar:300-Quadriceps:300-Hamstring:300-Gluteus:300-Duration:20 min

Main Training Protocol: Stimulation frequency: 65 HZ-Impulse durations:45 s-Impulse break:10 s-Amper:35-Depth Muscle-Abdominal:400-Lumbar:400-Quadriceps:400-Hamstring:400-Gluteus:400

Figure 3

Electrical Muscle Stimulation Device

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2.4. Data Analysis

Descriptive statistics were employed to ascertain the mean, variance, standard deviation, and range of changes. Subsequently, the Kolmogorov-Smirnov test was utilized to evaluate the normal distribution of the data. To analyze changes both within and between groups, the Multivariate Analysis of Covariance (MANCOVA) was applied. Hypothesis testing was performed at a significance level of less than five percent, utilizing SPSS software, version 24.

3. Findings and Results

Descriptive data pertaining to the demographic characteristics of the sample, including age, height, and weight of participants, are detailed in Table 1. The outcomes of the independent t-test revealed no significant discrepancies between the two groups regarding these demographic variables (P > 0.05). Additionally, the results of the Kolmogorov-Smirnov test confirmed the normal distribution of measurement variables in both the pre-test and post-test (P > 0.05).

Table 1

Demographic Characteristics of Participants

Variable	Group	Mean	Standard Deviation	Minimum	Maximum
Age (years)	Experimental	67.1	2.68	65	73
	Control	67	2.82	64	73
Height (centimeters)	Experimental	152.9	5.8	143	162
	Control	155.9	5.83	145	167
Weight (kilograms)	Experimental	68.9	8.6	58	83
	Control	68	12.44	58	93

As indicated in Table 2, there was no significant discrepancy in the pre-test scores of static balance and self-efficacy between the two groups. Considering the normal distribution of static balance and self-efficacy scores among the elderly participants, MANCOVA was employed for comparative analysis. The assessment of data characteristics confirmed the statistical assumption of homogeneity of variance-covariance matrices for the variables (P > 0.05), thereby justifying the use of Wilks' Lambda index to determine the significance of the multivariate effect. The Wilks' Lambda MANCOVA revealed that the group's influence on the linear combination of dependent variables was statistically significant (P < 0.05). This implies that there exists a statistically significant difference between the two groups in at least one of the assessed components.

Table 2

Descriptive Statistics of Static Balance and Self-Efficacy among the Elderly in Pre-test and Post-test

Variables	Groups	Box's M Test	Pre-test	Pre-test	Post-test	Post-test	Levene's Test in Pre-test	Levene's Test in Pre-test	Independent T-test in Pre-test	Independent T-test in Pre-test
		p	Mean	Std Dev	Mean	Std Dev	F	Sig	t	Sig
Static Balance (Biodex Test)	Experimental	0.071	1.42	0.73	2.46	1.55	0.926	0.349	-0.372	0.714
	Control	0.071	1.53	0.57	1.53	0.68	0.926	0.349	-0.372	0.714
Static Balance (Romberg Test)	Experimental	0.10	0.001	0.001	0.4	0.51	16	0.001	-1.5	0.168
	Control	0.10	0.2	0.42	0.2	0.42	16	0.001	-1.5	0.168
Self-Efficacy	Experimental	0.292	166.7	8.16	137.6	16.91	13.703	0.002	1.447	0.493
	Control	0.292	142.8	20.34	142.5	18.78	13.703	0.002	1.447	0.493

As presented in Table 3, concerning the variable of static balance in the elderly, significant effects were noted for time, group, and the interaction between time and group. This suggests that electrical muscle stimulation exercises have a substantial impact on enhancing static balance in the elderly. Regarding the variable of self-efficacy among the elderly, while the effects of time and the interaction between time and group are significant, the effect attributable to the group alone is not. Consequently, the results imply that

Health Nexus
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electrical muscle stimulation exercises do not significantly influence the improvement of self-efficacy in the elderly.

Table 3

Analysis of Covariance with Repeated Measures Design Comparing the Effect of Electrical Muscle Stimulation Exercises on Improving Static Balance and Self-Efficacy among the Elderly

Variables	Homogeneity Test Significance Level	Time Effect (F)	Eta Coefficient (p)	Group Effect (F)	Eta Coefficient (p)	Time*Group Effect (F)	Eta Coefficient (p)
Static Balance (Biodex Test)	Pretest = 0.349 Pretest = 0.076	6.863	0.017 (0.276)	1.538	0.047 (0.159)	6.863	0.017 (0.276)
Static Balance (Romberg Test)	Pretest = 0.110 Pretest = 0.081	6	0.025 (0.25)	0.001	0.001 (0.99)	6	0.025 (0.25)
Self-Efficacy	Pretest = 0.053 Pretest = 0.080	22.5	0.001 (0.442)	3.503	0.048 (0.163)	7.669	0.013 (0.299)

4. Discussion and Conclusion

The primary aim of this research was to examine the effects of electrical muscle stimulation (EMS) on enhancing static balance and self-efficacy in elderly individuals. The findings revealed that EMS exercises significantly improved static balance in the elderly. However, these exercises did not exhibit a notable effect on the self-efficacy of this demographic. The results of this study, which highlight the effectiveness of EMS in improving static balance among the elderly, align with the findings of several studies (7 ,10 ,11 , 16-19). For example, Rafiei et al. (2022) explored the impact of an EMS system on the walking patterns and balance of male athletes. Their study concluded that EMS positively influenced walking patterns and balance, with an observed increase in center-of-pressure oscillations and improved oscillation displacement, thereby affirming the effectiveness of EMS. The current study supports the notion that EMS, by strengthening lower limb muscles, favorably influences walking patterns, foot pressure oscillations, and balance (17). Similarly, Shohani et al. (2020) investigated the effects of unilateral and bilateral electrical stimulation on improving balance in elderly individuals, finding that electrical stimulation could indeed enhance balance. Additionally, Tapa et al. (2022) assessed the impact of EMS combined with resistance exercises on physical and brain functions in middle-aged and elderly women. Their study reported significant improvements in walking speed, muscle strength, and balance tests after four weeks of intervention, suggesting that EMS in conjunction with resistance training is an effective approach to boost motor performance in this demographic (18).

In another related study, Nishikawa et al. (2021) evaluated the effects of EMS on muscle mass and balance in elderly individuals with dementia. The results indicated a significant enhancement in muscle mass and balance in the exercise group, underscoring EMS as a valuable intervention for increasing muscle mass and maintaining balance in the elderly (10).

The effectiveness of EMS (Electrical Muscle Stimulation) on balance can be elucidated by considering the initial response of skeletal muscles to strength training exercises. Research indicates that early strength gains are primarily due to the nervous system's adaptation to increased loads rather than hypertrophy of muscle fibers. The heightened muscle electrical activity during this period is attributed to enhanced recruitment of motor units, as well as the frequency and coordination of neural impulses from electrical stimulation. This could lead to improved motor learning and muscular coordination. Such changes are possibly a result of the central nervous system's reduced inhibitory influence on muscles, decreased sensitivity of Golgi tendon organs, or alterations in the neuromuscular junction of motor units. It seems that electrical stimulation can induce neural plasticity, potentially associated with changes in functional connections. This, in turn, leads to increased blood flow in the stimulated area, thereby augmenting hemoglobin concentration in regions where neural connections are reinforced (20). Furthermore, the findings of the current study can be interpreted through the lens of systems theory. This theory posits that balance maintenance and posture control are the outcomes of the interaction and functioning of various systems, including the nervous, muscular, and skeletal systems. The central nervous system processes information from visual, vestibular, and somatosensory inputs to gain awareness of the body's position and center of gravity in space. When necessary, it activates pre-programmed motor patterns to respond to the body's position. In line with this theory, electrical stimulation in targeted areas, by engaging primary muscular zones and brain points integral to balance, can effectively enhance balance (18). Balance control necessitates the involvement of three information processing domains: visual, vestibular, and somatosensory senses, central integration within the brain, and motor response. Any deficiencies in postural control, stemming from environmental factors or age-related degradation in these systems, can increase an individual's risk of falling. This decline in balance is often exacerbated by inactivity. Research has demonstrated that physical exercises and muscular stimulations can enhance postural control and reduce the likelihood of falls. A key study highlighted that two major contributors to functional instability are the role of proprioception and its anatomical stability. Proprioception is crucial for balance control. It is involved in the design and correction of endogenous motor commands both prior to and during the execution of a movement. The motion control system must accurately assess the current and evolving state of the joints to predict the complex mechanical balance resulting from their movement. In this context, proprioception provides optimal conditions for information acquisition and transmission to the central nervous system, a complex process uniquely managed by the proprioceptive sensory system. Proprioceptive input is essential for maintaining overall body stability and local area stability (functional joint stability). Post joint injuries or with aging, the capability and efficiency of proprioception diminish. Promptly restoring the injured individual to pre-injury levels, heightening awareness of joint position and movement, and improving dynamic and static stability are crucial (10). During EMS sessions, the recruitment of motor units and stimulation of deep muscular and joint receptors contribute to more coordinated movements and targeted muscle contractions. This leads to more effective muscle contractions and strength development through the recruitment of both motor and muscle units. Consequently, this enhances balance and overall motor performance in the elderly. Regarding the impact of EMS (Electrical Muscle Stimulation) on the self-efficacy of the elderly, the current study did not find significant effects, indicating that these exercises may not bring about notable changes in the elderly's psychological indices of self-efficacy. A review of the literature and existing research reveals a limited number of studies exploring the effectiveness of EMS on psychological indices, particularly on self-efficacy. One potential explanation for the lack of significant impact of EMS on these indices could be related to the duration of the electrical stimulation. In this study, an eight-week intervention was implemented, consisting of two 20-minute sessions per week, with the core training period lasting approximately four weeks. While this duration appeared sufficient to induce muscular and motor changes, it might not have been adequate for substantial psychological alterations. Furthermore, it is posited that changes in psychological indices, such as an increase in self-confidence, likely necessitate more extended periods to manifest.

The main goal of this study was to evaluate the effects of electrical muscle stimulation (EMS) on enhancing static balance and self-efficacy in elderly individuals. The results indicated that EMS exercises significantly improved the static balance of elderly women, thereby bolstering their overall balance. However, these exercises did not yield a significant impact on the self-efficacy of the elderly.

Authors' Contributions

Study concept and design, M.R; Acquisition of data, M.A; Analysis and interpretation of data, M.A; Drafting of the manuscript, M.A; Critical revision of the manuscript for important intellectual content, M.R.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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