

Effect of physical and mental and combined exercises with the different sensory inputs on the dynamic balance of stroke patients

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ABSTRACT

Background and Aim: One of the most common problems in the stroke patients is reduction of balance and control of the posture and functional mobility disorders. Therefore, the purpose of this study was the effect of the selected physical and mental and combined exercises on balance of the stroke patients by focusing on change in the sensory inputs. **Methods:** Current research is of semi-experimental type, and it is applied in terms of purpose. Statistics population of research composed of the male stroke patients who are between 40-60 years old that visited the rehabilitation clinics in Shiraz city. 104 stroke patients participated in this research voluntarily. This research included 13 groups, 12 groups of which were considered as the experimental groups and one as the control group. Experimental groups were composed of 4 groups of the physical activity, 4 groups of the combined physical and 4 groups who did the subjective imagery exercise. Intervention of the experimental groups were done in 2 weeks; 5 consecutive days per week and 3 hours each day. Static balance assessments were done by the force plate device before the interventions start, immediately and 3 months after completion of intervention. To check the research hypothesizes, a compound variance analysis plan was used with 3 (types of exercises) * 2 (types of eyesight) * 2 (types of surfaces) * 3 (tests steps), which the last factor itself had variable with the repetitive measures. In this research, the software SPSS version 21 was used for analyzing the Data and 0.05 was considered as the significant level. **Findings:** The results of the combined analysis of variance for the static balance test showed that the main effect of exercise, and the main effect of the test steps was significant. Also the interactive effect of eyesight on the surface and the interactive effect of exercise on the surface were significant. The interaction of the eyesight in the test steps and the interaction of the eyesight on the surface in the test steps were not significant. The results of the combined analysis of variance for the dynamic balance test in the anterior-posterior axis showed that only the main effect of the test, and the interactive effect of the exercise on the surface are significant, and other effects were not significant. **Conclusion:** In this research it has been shown that physical and combined exercises have more effect on the statistic balance of these people, comparing to the imagery exercise, while it is shown that subjective imagery has a positive effect on the balance. In addition, it was shown that exercise on the ribbed surface has more effect comparing to the normal surface (flat surface) in some variables.

Keywords: Stroke, Balance, Mental imagery, sensory inputs.

Introduction

Brain vascular events can be defined as a sudden dysfunction in the central nervous system resulted from the cerebrovascular

disease, and they changes parts of body function and physical perception of body condition ^[1]. The prevalence of stroke in Iran is significantly higher than the most Western countries and occurs at an earlier age ^[2]. One of the problems common in the stroke patients is the loss of balance and postural control, which it leads to the increased chances of falling and uncertainty about walking in these patients ^[3]. One of the important factors in the successful walking, is the dynamic balance in the individual, so that some techniques are needed to help the patient maintaining the body weight and their balance control to help them go back to walk ^[3]. Maximum intentional muscle strength and weakness are one of the common clinical symptoms in the stroke patients ^[4]. Reduced power, speed, and motion control are observed in

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most patients, which can reduce functional ability. The causes of these disorders are the reduced muscle fiber, atrophy of fast contraction fibers, fatigue, and change in the motor mobilization [5]. Mechanical changes induced by stroke are considered as a limiting factor for the muscle contractions and intentional activity of muscles. Motor weakness, abnormal, and spasticity motor synergists leads to change of the walking patterns and these factors contribute to the balance weakness and risk of falling [3]. Balance is a complex motor skill that describes the body's dynamics in preventing fall. From a biomechanical point of view, balance is defined as the ability to maintain or reverse the center of the body gravity within a stable range determined by the level of reliance [6]. Stroke rehab is an organized effort to help patients to increase all opportunities available to return to the active lifestyle [7]. Over the past two decades, great advances in neuroscience have led to create of new concepts in rehabilitation interventions after stroke, including: sports exercises, mental imagery, physical exercises with the homework-centered approach, intensive physical exercises, physiotherapy, virtual reality, and the use of advanced and expensive devices such as TMS, etc., which have been introduced to accelerate the improvement of balance during rehabilitation. But in general, while stroke is one of the main causes of disability, there is still generally no accepted approach for the rehabilitation of the stroke individuals [8-13]. Mental imagery is the mental repetition of an action, without physical movements. Different theories justify the facilitating impact of mental imagery. Studies have shown that mental imagery stimulates brain and muscle activity and improves motor and cognitive function in the absence of physical movements [14-16]. Zimmermann Schlatter et al. (2008) investigated the effects of motor imagery on individuals with stroke. The results of this study showed that the use of motor imagery can have far more advantages in physiotherapy and rehabilitation in individuals with stroke [17]. Compressed physical exercises are referred to as a series of practice sessions, in which the ratio of exercise time to rest is high, and the amount of rest between the exercise times is relatively less than the amount of time spent to the exercise [18]. In a research conducted by Adomitis and colleagues in 2005, the effect of intensive exercises on the post-stroke balance rehabilitation was investigated. In this study, 10 patients exercised 6 hours a day for 10 consecutive days. The results of this study showed that the intensive compressed exercises can increase the function of the damaged member after stroke [19]. In a study, Biyok et al. examined the effect of the compressed exercise program, with changes in the sensory inputs, on the balance of stroke individuals. The results showed that an exercise program with a change in the sensory input, is more effective in improving the balance of stroke individuals than the same exercise program without the sensory inputs change [20]. The maintenance of balance involves the complex sensory changes that involve several types of sensory information (visual, sensory-body, and vestibular) [21, 22]. Stroke causes disturbances in the lower extremity sensory system, including: disability of the nervous system in accuracy of understanding, processing and

interpreting the sensory feedback [7]. To some extent, the results of the research show that by manipulating and changing the sensory inputs during rehabilitation, individuals can challenge their balance and improve the stability of the balance [20, 23]. In individuals with chronic stroke, the motion patterns learning process and the use of the affected organs are negatively affected with the loss of motor function by passing time. And as a result, the internal sensory data decreases and therefore, the sensory-motor integrity is disturbed or damaged. These factors can limit their balance and functional mobility. As a result, some exercises should be designed to challenge somatosensory and eyesight information and in the individual, this can result in sensory compensation and ultimately, improves the sensory-motor integrity in the central nervous system, and this will coordinate and activate the motor process and finally leads to the improved muscle synergies and increased state control [19, 20]. Given the above mentioned notes, various therapeutic approaches have been tested to improve balance, but the range of results has been variable. In a systematic review, there is no evidence of superiority of a method alone on other methods, for balance and sensory control of lower extremity of stroke patients. Considering that balance is the main component for performing many functional and mobility activities, this study attempted to investigate the effects of physical, mental and combined physical exercises, with different sensory inputs, on the dynamic balance of stroke patients.

Materials and Methods

Current research is of semi-experimental type, and it is applied in terms of purpose, and the research design is a post-test pre-test with the control group. After confirmation of the plan by Ethics Committee in Biomedical Research of Shiraz University of Medical Sciences (IR.SUMS.REC.1395.95), 104 patients with stroke aged between 40 and 60 years' old who visited the rehabilitation clinics in Shiraz city, were selected voluntarily after the initial interview and being informed about the research conditions. Patients were evaluated before and after the intervention. The criteria for entering this study were: they should be patients with the first stroke; they should be aged between 40 and 60; at least 6 months have passed since their stroke; being able to stand up alone; Can walk 30 meters with or without the partial assistance; Being able to follow verbal commands; with no disturbances in the balance and control of the trunk before the stroke; No severe heart problems; Lack of arthritis in the joints, especially the knee and spine; having normal eyesight; Being at least literate to read and write, and being normal mentally, behaviorally and in terms of comprehension. Before the intervention, all patients were tested for the dynamic balance. Information about the mental imagery of the triable subjects was obtained through the vividness of movement Imagery Questionnaire (VMIQ-2). In this study, there were 12 experimental groups and one control group. The experimental groups respectively consisted of 4 groups of physical activity (with and without the eyesight at the

normal surface, with and without the eyesight at the ribbed surface), 4 groups of mental imagery exercises (with and without the eyesight at the normal surface, with and without eyesight at the ribbed surface) and four groups of physical training and mental imagery (with and without the eyesight at the normal surface, with and without eyesight at the ribbed surface). Intervention of the experimental groups were done in 2 weeks; 5 consecutive days per week and almost 3 hours each day; half an hour of which was the rest between the exercises. First part of the practice protocol was: 1) step on the practice stairs from front, back and from inside and outside of the foot. 2) Walk between obstacles at different heights with a distance of 1 meter in a 10-meter course. 3) Get up from the chair, walk 4 steps forward and touch the foot with a stool (once with the right foot and once again with the left foot), then turn and go back to the chair. 4) Get up of the chair, walk 4 steps forward, rotate right and step on the practice stairs, and then turn right and back and walk toward the chair (this training cycle was performed once again by turning to the left). Second part of the practice was: 1) Standing on two legs without help for 30 seconds. 2) Standing on the superior leg without help for 10 seconds. 3) Standing on the non-superior leg without help for 10 seconds. 4) Standing in a form that heel of one leg is along the back tow for 10 seconds. 5) Walking on a 10-meter track on the toe and heel. 6) Get up of the chair without using arms. Each item had two replications in the 10-item sport exercise mentioned above; In the physical groups, the first 4 items were the same for all people with open eyes and with the specific surface of each group, and the last 6 items was done with the conditions related to each group. The other four groups, which consist of a combination of the physical exercises and mental imagery, represented each item once physically and once again with mental imagery (using the audio instruction). In the mental-motor imagery group, they visualized the physical activity and imagined themselves as they progressed by using the audio instruction in their minds. Dynamic balance was achieved by walking and crossing the force plate; People were walking in a specified 10-meter rout, while they did not know about the location of the force plate in which. Each person was tested 3 times for the reliability increase. After completing the exercises and three months later, the tests were repeated. In this study, Kvmogrvf Smirnov (ks) and Levens tests were used respectively to determine the normality of the data and homogeneity of variance of the groups; and in order to check the research hypothesizes, a compound variance analysis plan was used with 3 (types of exercises) *2 (types of eyesight) *2 (types of surfaces) *3 (tests steps).

Findings

A total of 104 male stroke patients with an average age of 54 ± 6/43 participated in this study in 13 groups. The mean and standard deviation of the dynamic balance on the two anterior-posterior and inward-foreign axes were shown in Table 1-1.

Table 1-1 Mean and standard deviation of the dynamic balance in two anterior-posterior and internal-foreign axes

Step	Exercise type	Eyesight	Surface type	mean and standard deviation of anterior-posterior	mean and standard deviation of inward-foreign
Pre-test	Physical	With	Normal	51.43±3.08	24.82±3.57
			Ribbed	48.64±3.37	25.10±4.08
		Without	Normal	48.64±4.08	23.80±2.21
			Ribbed	52.11±1.97	26.34±2.41
			Normal	49.23±3.71	24.2±3.58
			Ribbed	48.81±3.90	25.42±3.2
	Mental	With	Normal	47.57±2.65	26.79±2.06
			Ribbed	50.75±3.97	23.33±2.81
		Without	Normal	51.32±2.02	22.89±2.44
			Ribbed	49.50±2.76	26.18±1.8
			Normal	51.13±2.62	27.01±1.86
			Ribbed	49.82±1.69	23.14±2.74
First reminder	Physical	With	Normal	46.81±3.40	22.43±3.71
			Ribbed	45.25±4.38	22.43±3.71
		Without	Normal	46.11±3.45	22.06±2.62
			Ribbed	47.32±3.89	21.54±3.67
			Normal	48.11±4.19	20.58±0.69
			Ribbed	47.90±4.38	23.96±2.18
	Mental	With	Normal	44.90±2.57	24.12±2.64
			Ribbed	45.08±3.16	20.46±2.45
		Without	Normal	48.11±3.78	19.20±1.81
			Ribbed	45.70±2.64	23.78±2.76
			Normal	46.90±5.01	23.7±2.82
			Ribbed	44.10±2.65	21.42±3.88
Second reminder	Physical	With	Normal	45.11±4.35	21.33±3.58
			Ribbed	44.49±3.89	20.96±3.92
		Without	Normal	45.66±5.34	20.51±3.89
			Ribbed	46.90±2.42	20.24±3.11
			Normal	47.15±3.55	22.16±3.07
			Ribbed	47.01±2.59	23.21±1.67
	Mental	With	Normal	45.13±2.45	21.08±1.71
			Ribbed	45.18±4.69	21.12±3.04
		Without	Normal	47.12±3.36	19.63±2.73
			Ribbed	43.2±2.78	22.10±3.06
			Normal	45.14±3.35	22.32±3.23
			Ribbed	43.41±2.37	21.13±3.31

The results of the compound variance analysis used to test the dynamic balance in the foreign-domestic axis showed that the main effect of the exercise $F(2,84)=4/57$, $P=0/01$, $\eta^2_p=0.09$, the main effect of the test steps, $F(2,168)=19/08$, $P=0/0001$, $\eta^2_p=0/18$ were significant. In addition, interactive effect of eyesight in the surface, $F(1,84)=14/34$, $P=0/0001$, $\eta^2_p=0/14$, and eyesight interaction on the surface, $F(2,84)=3/81$, $P=0/02$, $\eta^2_p=0/08$ were significant. Eyesight interaction in the tests steps, $F(2,168)=1/07$, $P=0/34$, $\eta^2_p=0/01$ and eyesight interaction on the surface in the tests steps, $F(2,168)=1/52$,

$P=0/22$, $\eta^2_p=0/01$ were not significant. Other effects were not significant, all $F<1$. For the main effect of the exercise, the Bonferroni post hoc test was performed that results of which showed that the physical and combined modes differ significantly from the mental modes, all $P<0/05$. But differences between the physical and combined modes were not significant, $P>0/05$. Comparison of means showed that the physical and mental modes had a better performance than the mental state (means, physical= 22/05, mental=23/10, combined=22/24). For the main effect of the test, a post hoc test was performed that result of which showed that the first and second reminder tests had a significant difference with the pre-test, all $P<0/05$. But difference between the first and second reminder tests, $P>0/05$. Comparison of means showed that participant in the first and second reminder tests had a better performance than the pre-test (means, pre-test= 23/87, first reminder=22/19, second reminder =21/31). For the interactive effect of visual exercise, a post hoc test was performed, result of which showed that although the effect of surface is not significant, exercise on the ribbed surface will have a better performance than the normal surface in the mental and combined modes without eyesight, $P<0/05$. The results of the compound variance analysis, used to test the dynamic balance in the anterior-posterior axis, showed that only the main effect of the exercise, $F(2,168)=33/67$, $P=0/0001$, $\eta^2_p=0.28$, and the interactive effect of the exercise on the surface, $F(2.84)=3.59$, $P=0/03$, $\eta^2_p=0.07$ were significant. Other effects were not significant. For the main effect of the exercise, the Bonferroni post hoc test was performed that results of which showed that difference between the first and second reminder tests with the pre-test was significant, all $P<0/05$. But there was not a significant difference between the first and second reminder tests, $P>0/05$. Comparison of means showed that participant in the first and second reminder tests had a better performance than the pre-test (means, pre-test= 49/40, first reminder=46/35, second reminder =45/48). For the interactive effect of exercise on the surface, a post hoc test was performed, result of which showed that in the combined mode, there is a significant difference between the normal and the ribbed surface, $P<0/05$, and comparison of means showed that exercise on the ribbed surface has the more positive effect on balance, on the anterior-posterior axis (means, normal surface =48/09, ribbed surface=45/87).

Discussion

In this research, it has been shown that all three types of exercise (physical, mental, and combination) have a positive effect on all of the dynamic balance indices, but the physical exercise and the combined exercise had a more positive effect on the mental practice. It was also shown that the combined exercise did not have a significant difference comparing to the physical activity, and the effect of these two types of training was approximately equal. These findings, that shows that the combined exercise has a greater impact comparing to the

physical activity, are not consistent with earlier studies in this field [24-26]. Chu et al. (2013) examined the effect of the motor imagery exercise on the balance and walking abilities in people with stroke. The results showed that the walking exercise together with the motor imagery, makes the balance abilities of people with stroke far better than walking alone [24]. Liu et al. (2004) examined the combination of the physical exercises and the mental imagery in rehabilitation of the stroke individuals. The results of this study also showed the higher levels of progression in the combined group [25]. Jackson et al. (2004) studied the effectiveness of the physical and mental exercises in the learning and rehabilitation of people with stroke. The results of this study showed that the mental exercises with the physical exercises can improve the continuous performance of people with stroke, and it shows that the mental exercises play an important role in the abilities of these patients [26]. The nature of the task was the probable cause that the combined exercise did not have a greater impact comparing to the physical activity. By the nature, the task used in this study is the motion task that has less cognitive components comparing to many tasks used in the research relating to cognitive –motor. Based on the cognitive –motor hypothesis, imagery is more influential in tasks that have the cognitive aspect [27]. Accordingly, it is likely that the motor aspect in this task has made it impossible to see a great effect of cognitive –motor, and this does not make the combination group superior. This argument is more evident based on the results of the illustration. Although in most cases, exercise in the imagery form contributed to progress in balance indices, but the rate of progression of combined and physical groups was consistently lower. This argument is based on the results of the imagery. Although in most cases, exercise in the imagery form contributed to progress in the balance indices, but it was consistently lower than the rate of progression of the combined and physical groups. In this study, it was found that all types of the existing exercises, improve balance indices, that is consistent with the simulation theory [28]. Based on this theory, all types of practice have similar mechanisms, which use a same type of the subjective representation. Consistent with this theory, it was observed in this study that either physically or mentally or/ in combination exercise would improve the balance of individuals, that is somehow confirming this theory [28]. In this study, it was observed that exercise on the ribbed surface was more effective in some balance indices, rather than practice on the normal surface. These findings are in line with the findings of Bapuk et al. 2006, which indicates the effect of the level on individuals' balance [29, 30]. Bayouk et al. (2006) examined the effect of the exercise programs with changes in sensory inputs, on the balance of stroke individuals [29]. The exercise was such that the control group experienced the normal conditions in the exercise, and the experimental group was practicing under the eyesight and surface manipulation conditions. There were four sensory conditions in the experimental group: (1) Open eyes, normal levels. (2) open eyes, soft surface. (3) closed eyes, normal surface and (4) closed eyes, soft surface. The results showed that an exercise program with a change in the sensory input was more effective in

improving the balance of stroke patients, than the same exercise program without changing the sensory inputs^[29]. To investigate the effect of the sensory-body information change on the situation stability, Quo et al (2011) performed the static balance test under three surfaces of shoe insole: 1. barefoot 2. soft patterned surface 3. rigorous patterned surface on the 7 elderly and 21 healthy young. Participants were tested by two visual conditions (open eyes and eyes closed) and two surface of standing (foam and rigid). The older group showed a more posture fluctuating region than the young group, in the barefoot conditions on the rigid and foam surfaces. In general, measuring the postural fluctuation region showed that only the older group benefited from the use of different surfaces of shoe insole. The results of this study showed that both shoe insole surfaces reduced the posture fluctuation^[30]. But in this research, it was further attempted to help improve the balance of people by emphasizing on stimulation of the foot receptors, using the ribbed surface; since it has been shown that these receptors can play an important role in balancing these individuals^[31], and these findings are themselves confirming this claim. In this study it was also shown that in some cases, exercising under the eyesight conditions leads to effect on the balance of individuals more than practicing in the absence of eyesight. These findings indicate the role of eyesight in the process of control of posture^[32]. As shown in previous studies, the performance is negatively affected by the removal of the eyesight system. (Quo et al., 2011, Boyoke et al., 2006). The results of this study are in line with the results of Guillermo 2002, Perrin 2002, Williams 2002, Simons 2005, Harring 2008 and Meshkati in 2010. A significant result was obtained in this study, which is of the particular importance. In this study, it has been shown that in some cases, when people in the imagery group use their eyesight in their exercises, they do not have a significant difference with the physical and / or combined mode, and there is difference only when the group of imagery don't use their sense of eyesight. This finding shows the importance of two issues. The first issue is the full use of all senses when practicing and imagery. This view is now widely accepted by the researchers, and is included in a new approach of imagery, called Phettelp^[33]. Based on this model, the use of all senses during the imagery will increase its effectiveness. Accordingly, it is likely that the lack of sense in the absence of eyesight (of course in the physical exercise) may lead to performance degradation. This result also indicates the importance of previous experience in imagery^[34]. According to this view, the imagery has the most impact in people who already practiced all the senses involved in the task. Therefore, it is likely that lack of the enough prior exercise of individuals (in the physical mode and in the presence of eyesight) has resulted in performance degradation in the imagery mode.

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