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Original Article

Investigating the Effect of Cognitive and Sensorimotor Exercises on the Functional Balance of the Elderly

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Abstract

Background and aims: The elderly living in nursing homes have different motor situations compared with their peers, which can affect different motor functions. Investigating the characteristics of balance has always been of interest to researchers due to its importance in the functional independence of the elderly. Thus, the present research aimed to investigate the effect of cognitive and sensorimotor exercises on the functional balance of the elderly.

Methods: This quasi-experimental study was performed with the intragroup comparison design, as well as pre- and post-test measurement stages in Iran during 2017. A total of 60 elders were chosen through the convenience sampling method. Accordingly, the subjects were matched in four groups after performing the pretest with demographic, physical activity readiness, and Mini-Mental State Examination questionnaires and Tinetti test. Each group performed eight exercise situations lasting for 5-10 seconds by taking the overload principle into account throughout 24 sessions. The statistical population of this research consisted of the elderly living in nursing homes under the supervision of the Welfare Organization of Shiraz, including 875 individuals. In general, 60 subjects were chosen through a voluntary method (age: 61.7 ± 7.6 years old, weight: 65.2 ± 16.2 kg, and height: 157.7 ± 6.7 cm). During the data collection, 14 subjects left the study for different reasons. The balance characteristics were measured by the Tinetti test. Finally, statistical analysis was performed through the difference of the scores of measurement stages and by one-way ANOVA and Tukey post hoc tests.

Results: The comparison of cognitive, sensorimotor, and combined groups with the control group regarding the dependent variables of the research indicated that cognitive exercises have no significant effect on balance ($P=0.103$), while the sensorimotor ($P=0.002$) and combined ($P=0.002$) exercises were effective on balance.

Conclusion: In general, the significance of the balance following sensorimotor and combined exercises compared to the insignificance of cognitive exercises can highlight the importance of sensorimotor exercises in the balance of the elderly living in nursing homes.

Keywords: Cognitive and sensorimotor exercises, Balance, Senescence, Elderly

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Introduction

The international community is moving toward senescence at an alarming rate. In this period of human life, different cognitive, emotional, psychological, and motor dimensions have changed significantly. Some of them are positive, while some others can be considered negative. The regressive changes of the neuromuscular system are among the negative ones related to senescence. These changes can develop some risks for the elderly, including balance loss. Based on previous research conducted in Iran, 36.6% of the elderly were depressed and 22.5% did not participate in any kind of sport activities.[1] The impairment in controlling balance and walking characteristics increases the probability of falling on the ground. In addition, the risk of falling is very high among the elderly, where the probability of the alteration of patterns also increases with aging, mostly resulting in different injuries including fracture and even death for the elderly.[2] Facing balance disturbances, the elderly may lose their balance and fall on the ground if they cannot have a suitable reaction. This might be due to diminished neuromuscular function and reduced flexibility in different joints controlling the balance with failure.[3] The loss of muscle mass and the alteration of the muscle structure reduce the muscular power and

strength, which further complicate these failures.[4] Previous evidence suggests that one can help the elderly to return to their normal routine lives by enriching the growth context and developing suitable exercise opportunities. Functional balance controlling skills constitute the basis that forms all bodily movements. Therefore, childhood and the beginning of adolescence ages are regarded as the best time for the growth of these skills and thus should receive special attention.[5] With aging and reaching the senescence period, these controlling skills get weakened and lose their basic functions in meeting the person's needs. Functional balance controlling exercises, along with fun games, are considered an important factor in the growth of functional balance skills. Further, it seems that purposeful and planned games are among the best solutions for facilitating motor-functional control recovery in this group as they involve motor, thinking, and competition elements.[6]

Accordingly, balance is considered essential for performing many motor skills. It is also evident that this competence becomes further important for solving motor problems in individuals with special physical conditions. Motor skills act as a basis for improving higher brain function which improves motor and cognitive functions of the elderly.[7]

Furthermore, purposeful movements need integration between the nervous system and the other organs and systems of the body. The central nervous system (CNC) should be able to identify and perceive sensory inputs, make proper decisions, and act at correct timing and coordination in order to perform movements. Across all these activities, the brain needs a series of actions called information processing, where each stage needs a certain time that is measured by the reaction time. Moreover, the reaction time is an indirect index for measuring the processing ability of the CNS and also a simple means for determining the relationship of sensorimotor function, because it necessitates involving the CNS mechanisms. Additionally, the reaction time refers to the interval between the sudden presentation of a stimulus until the initiation of a response, which is categorized into preemptor and movement time parts. Different studies investigated performing exercises that highlight the stimulation of the systems involving balance. The results of the study by Fritzen et al. showed that one can expect positive effects if the duration and type of exercise are chosen and implemented properly.[8] However, combining different cognitive, sensory, and muscular exercises can also develop possible effects that even might be different from special exercises. Regarding this issue, Islam et al employed the combination of sensory and muscular exercises in the elderly group and concluded that balance is improvable.[9] Nevertheless, contradictory results exist regarding the balance and walking characteristics of the senescence period. Ghasempour et al investigated the effect of 12 weeks of functional exercise on dynamic balance of healthy elderly women. The experimental group participated in a 12-week schedule of functional exercises for 3 sessions per week. On the other hand, the dynamic balance of the control group did not change significantly after 12 weeks of functional exercise. The time of the 'timed up and go' (TUG) test as an index for dynamic balance decreased significantly in the experimental group in terms of both inter- and intragroup. In another study, Ghasempour et al indicated that functional exercises can effectively improve the dynamic balance of healthy elderly women and have a positive effect on their lives.[10] Smith-Ray et al evaluated the effect of cognitive exercises on the balance in the walking of the elderly. After 10 weeks of performing cognitive exercises, the TUG test was conducted on the subjects. Based on the results, the experimental group showed a significant improvement in TUG test.[11] Similarly, Targino et al studied the effect of hybrid exercises on controlling the static balance of the elderly. The duration of this research was four weeks and two 45-minute sessions were held each week. The exercises were performed on a treadmill, while visual stimulation exercises were used as secondary tasks. Performing hybrid exercises was considered only for the experimental groups. The results indicated that these exercises improve the function of individuals, especially regarding static balance.[12] On the other hand, most of the other studies have less dealt with investigating the effect of hybrid exercises on motor skills. It seems that identifying the effect of exercises, which mostly considers systems involved in the movement especially balance, remains understudied. Thus, the aim of this research was to evaluate the effect of combining sensory and cognitive exercises on the static and dynamic balance of the elderly.

Methods

The present study was a quasi-experimental research with an intragroup comparison design with pre- and post-test measurement stages. The statistical population of this research consisted of 875 elderly living in the nursing homes under the supervision of the Welfare Organization of Shiraz, out of whom 60 cases were chosen through the convenience sampling method (age: 61.7 ± 7.6 years old, weight: 65.2 ± 16.2 kg, and height: 157.7 ± 6.7 cm). In the course of sampling stages, 14 individuals decided to discontinue the study for different reasons. The inclusion criterion included literate people and the exclusion criteria were mothers with a history of musculoskeletal disorders, a history of musculoskeletal surgery, and participants who became psychotic and needed medications.

After the identification and the pretest, the subjects were randomly categorized into 4 groups and each group performed eight exercise sessions lasting for 5-10 seconds three times a week for eight weeks.[1] Within the same duration, the control group dealt with routine occupational therapy exercises with the exercise groups. First, the group practicing sensorimotor exercises were

trained by the researchers and dealt with improving the sensory components of balance including somatosensory, vestibular, and visual receptors. Then, they began the exercises from the exercise situation 1 and proceeded to exercise situation 8 based on the gradual overload principle. The cognitive exercise group dealt with performing cognitive skills including exercises for attention, memory, processing speed, thinking, problem-solving, visual processing, and auditory processing after 10 minutes of general warm-up. Finally, the combined group performed a combination of cognitive and sensorimotor exercises and received exactly the same activities from the first and second groups simultaneously.

Research Instruments

Demographic information questionnaire: It included the date of birth, weight, height, and body mass index of the subjects.

Physical activity readiness questionnaire: It was used to measure the physical preparation status of the subjects in order to enter the research. The medical history questionnaire consisted of 14 questions in which information including the situation of the central nerves system health, vision, audition, surgery, and medication consumption was used to investigate the status of their balance. It included 19 questions and had a total score of 30. The internal consistency was reported to be 0.81-0.85 by the test-retest method.

Cognitive questionnaire: This instrument was utilized to investigate the cognitive status of the subjects and the Mini-Mental State Examination test validated by Seyedian et al was utilized (r=0.84) to ensure that the subjects were not affected by senile dementia. The individuals could step into the next stage of the research if they acquired a score of at least 24.

Measuring the balance: The balance scores were measured in the pre- and post-test stages using the Tinetti test. This test, which was first introduced in 2007 for the elderly, has 16 items in which scores 0-2 are assigned to each item based on the performance of the subject. The internal consistency was reported as 0.72-0.85 by the test-retest method.

Results

Table 1 represents the frequency distribution of the subjects across the research groups.

As shown in Table 1, 29 women and 17 men performed cognitive, sensorimotor, control, and combined exercises. In addition, Table 2 presents the demographic information of each individual group.

The mean and standard deviation of age, weight (kg), and height (cm) are provided in Table 2. The average age of the participants is 67.00 and its standard deviation is 8.252. Further, their average weight and the standard deviation are 65.57 and 13.058, respectively. Similarly, the average height of participants and its standard deviation are 159.48 and 8.046, respectively. Based on the results, there is no difference between the groups regarding the presented characteristics ($P>0.05$).

Table 3 demonstrates the distribution of the frequency, mean, and standard deviation of four static equilibrium states including four premiere foot (open eyes), non-

Table 1. The Frequency Distribution of Respondents Based on Gender

Gender	Exercises				
	Cognitive	Sensorimotor	Control	Combined	Total
Female	9	5	7	8	29
Male	5	5	4	3	17
Total	14	10	11	11	46

Table 2. The Demographic Characteristics of the Subjects

Exercises	Statistic	Age	Weight (kg)	Height (cm)
Cognitive	Number	14	14	14
	Mean	67.79	66.36	159.50
	Standard deviation	7.698	11.894	7.262
Sensorimotor	Number	10	10	10
	Mean	61.70	65.20	157.70
	Standard deviation	7.602	16.226	6.701
Control	Number	11	11	11
	Mean	70.09	65.73	159.91
	Standard deviation	8.949	12.297	12.153
Combined	Number	10	11	11
	Mean	67.80	64.73	160.64
	Standard deviation	7.480	13.907	5.464
Total	Number	45	46	46
	Mean	67.00	65.57	159.48
	Standard deviation	8.252	13.058	8.046

Table 3. Static Equilibrium Table for Contributors

Group	Statistics	Variables							
		Premiere Foot (Eyes Open)		Not Premiere Foot (Eyes Open)		Premiere Foot (Eyes Closed)		Not Premiere Foot (Eyes Closed)	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Cognitive	Number	14	14	14	14	14	14	14	14
	Mean	2.257	3.060	2.084	3.120	1.035	2.249	0.936	1.735
	Standard deviation	2.257	3.060	2.084	3.120	1.035	2.249	0.936	1.735
Sensory-movement	Number	0.988	0.547	1.196	0.683	2.095	2.020	0.906	0.885
	Mean	10	10	10	10	10	10	10	10
	Standard deviation	3.020	1.960	2.930	1.440	4.659	2.490	9.550	5.780
Control	Number	2.346	2.150	1.282	1.271	1.638	0.980	5.140	4.631
	Mean	11	11	11	11	11	11	11	11
	Standard deviation	1.174	1.364	1.806	1.181	2.950	3.009	6.294	3.245
Combinatorial	Number	0.653	0.883	1.376	1.644	1.918	1.709	6.002	1.763
	Mean	11	11	11	11	11	11	11	11
	Standard deviation	2.362	1.391	2.681	1.372	4.318	2.172	6.655	3.063
Total	Number	1.954	1.259	1.243	0.826	2.633	1.783	5.009	2.711
	Mean	46	46	46	46	46	46	46	46
	Standard deviation	2.030	1.370	2.394	1.382	3.700	2.414	6.104	3.452

premiere foot (open eyes), premiere foot (closed eyes), and non-premiere foot (closed eyes). The results indicated that in the pre-test, the premiere foot movement (open eye) had a mean of 3.452 and a standard deviation of 2.921, but in the post-test, the mean was 6.104 and the standard deviation was 4.963. Furthermore, the movement of the non-premiere foot (open eye) represented a mean of 2.414 and a standard deviation of 1.692, but in the posttest, the mean and the standard deviation were 3.700 and 2.168, respectively. Besides, in the pre-test of the premiere foot (closed eyes), the mean and the standard deviation were 1.382 and 1.35, respectively, but in the post-test, the mean was 2.394 and the standard deviation was 1.296. Eventually, the non-premiere foot (closed eyes) had a mean of 1.370 and a standard deviation of 1.293 in the pre-test, but in the post test, the mean and the standard deviation were 2.030 and 1.688, respectively.

The measured variables of balance across different data collection stages by each individual group are summarized in Table 4.

Based on the results, the mean and the standard deviation in the cognitive training group in the pre-test were 20.07 and 4.17, respectively, and the corresponding statistics in the post-test were 21.46 and 4.32, respectively. In the sensory-motor training group, the means and the standard deviations were 20.40 and 8.83, as well as 22.70 and 3.65, in the pre-test and post-test, respectively. In addition, the control group had a mean and standard deviation of 21.27 and 3.22 in the pre-test and a mean and standard deviation of 22.00 and 3.55 in the post-test. The combined exercise group obtained a mean of 20.09 and a standard deviation of 3.36 in the pre-test, along with a mean of 22.36 and a standard deviation of 2.97 in the post-test.

Discussion

The ability of keeping and controlling the body gait in the space is considered as the outcome of a complex interplay between muscular, skeletal, and nervous systems. The importance of each system varies given the aim of movement performance and environmental conditions. Further, the CNS is informed of the situation related to the mass center of the body with respect to the gravity and the supporting surface conditions using the information of visual, vestibular, and somatosensory (including the sense of the situation of joints and peripheral sense) systems. Then, it activates a suitable motor response as preprogrammed motor patterns. Meanwhile, there are some major physiological mechanisms through which the body can be informed about the adaptations and thus manifests a series of reactions to preserve the status of the body. These mechanisms include pressure receptors in the feet, the vestibular mechanism of the ears, and the internal system of the vision. The results of this research indicated that cognitive exercises have no effect on the functional balance of the elderly. On the other hand, the affectability of balance by sensorimotor and combined exercises suggests the important role of exercises focusing on visual and vestibular systems, as well as joint receptors even after losing muscular characteristics and senescence-associated problems. The results of part of the research related to the lack of affectability of balance by cognitive exercises contradict the findings obtained by Smith-Ray et al[11] and Shamsipour-Dehkordy et al[13]. Shamsipour-Dehkordy et al used static balance and the Star Excursion

Table 4. Tinetti Test Table

Type of Exercises	Statistic	Pre-test	Post-test
Cognitive	Number	14	14
	Mean	20.07	21.46
	Standard deviation	4.17	4.32
Sensorimotor	Number	10	10
	Mean	20.40	22.70
	Standard deviation	3.83	3.65
Control	Number	11	11
	Mean	21.27	22.00
	Standard deviation	3.22	3.55
Combined	Number	11	11
	Mean	20.09	22.36
	Standard deviation	3.360	2.97
Total	Number	46	46
	Mean	20.43	22.13
	Standard deviation	3.316	3.606

Balance tests and suggested 8-week exercise sessions. These contradictory results can be attributed to the type of test and the different number of sessions. Furthermore, the difference in the tests utilized by Smith-Ray et al, on the one hand, and their different exercise methods, on the other, can be a justification for acquiring conflicting results in this research and the above-mentioned study[11]. In the present research, the results related to sensorimotor exercises are in line with the findings obtained by Islam et al, Targino et al, and Shamsipour-Dehkordy et al. These congruent results confirm the importance of dealing with these types of exercises in the daily programs of the elderly.[9,12,13]

Logic and thinking involve the ability of the concept of belonging and problem-solving using unfamiliar information or new methods. Moreover, visual processing involves the ability of receiving, analyzing, and thinking about visual images. Auditory processing (auditory awareness) includes the definition of processing, combining, and separating sounds. Eventually, improving long-term memory encompasses the ability of reminding information in the past. All these parameters had a positive influential role in keeping the static and dynamic balance of the elderly.

Over the last 100 years, humans have had awareness of body mechanism and found a significant base in this regard. The consequences of all this effort, searching, and finding are that today we can plan for better quality and quantity of human beings. Long life is one of the achievements of the 20th century. The increase in life expectancy at the end of this century has been emphasized for twenty years. Several factors such as improving nutrition and housing, as well as medical innovations such as vaccination and discovery of new antibiotics have led to a significant increase in the number of elderly people.[14] The most important factors affecting the aging population are mortality reduction, especially the death of infants and children, a substantial and continuous decline in fertility and, consequently, reduction in population growth that has caused major changes in the age structure of the population of most societies, including Iran. Given the growing population of the elderly, as a growing population with special needs, as well as the provision of appropriate services, it is inevitable to examine the indicators and issues of this group of people.[5]

Human movements start with and end to balance. In most cases, the motor system does not move, but it is only a matter of maintaining the body. In other words, a person is subject to a mechanism hierarchy in order to preserve excellence. Whether static or moving, humans need more of a kind of equilibrium called dynamic rather than static equilibrium. However, with respect to how to stand and move on 2 legs, gravity stretching is steadily trying to pull a person to the ground.

In general, different factors such as few numbers of subjects, the subjects' dropouts, their absence in exercises, as well as the psychological and motivational characteristics of the subjects were not controllable by the researcher. In future studies, special exercises of each sensory organ (i.e., visual, proprioception, and vestibular) can be included in the research as well.

Some of the limitations of this study were the psychological issues, along with individual and personality differences of the elders, which might have affected the results. The researcher definitely could not control these items. On the other hand, the small sample size was another limitation that may affect the generality of the result.

Conclusion

Given the positive impact of cognitive and sensorimotor skills on the functional static and dynamic balance of the elderly, as well as the importance and status of balance in old ages, it is emphasized that the elderly try to perform such exercises to improve their balance for doing daily routine activities. This effective method can always be used to enhance elderly health due to its easiness, inexpensiveness, and safety.

Ethical Approval

This study was obtained from the research project approved by the Department of Physical Education and Sports Sciences of Tehran University, Kish International Pardis University under the ethical code of 2502268 on September 22, 2018.

Conflict of Interest Disclosures

None.

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