

# Research Paper: Effect of A Six-week Dynamic Neuromuscular Stability Training on Performance Factors and Quality of Life in the Elderly



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## ABSTRACT

**Introduction:** The present study aimed to investigate the effects of 6 weeks of Dynamic Neuromuscular Stability (DNS) training on performance (lower limb strength, flexibility, fall risk) and quality of life in the elderly.

**Materials and Methods:** This was a quasi-experimental study with a pretest-posttest design. This research was performed on 30 elderly males, aged 60-70 years in Qom Province, Iran in 2021. The examined elderly were randomly divided into the experimental and control groups (n=15/group). Furthermore, the experimental group participated in three 45-minute weekly sessions of DNS training for 6 weeks. To collect the necessary information before and after applying the training protocol, tint tests, 30-second seat sitting test, sitting and delivery test, TUG test, and SF-36 questionnaire were used. The obtained data were analyzed using Analysis of Covariance (ANCOVA) and Paired Samples t-test at a significance level of 0.05.

**Results:** The ANCOVA results indicated a significant difference between the experimental and control groups in motor function, fall risk, quality of life, lower limb strength, and flexibility (P<0.05). The collected mean scores outlined that the experimental group performed better than the control group.

**Conclusion:** Due to the effectiveness of DNS training on physical function and the very high importance of the elderly lifestyle, it is recommended that the provided training protocol be used for prevention and rehabilitation, increase the level of physical fitness and quality of life as a low-cost treatment, among the elderly.

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## Introduction

**A**ging is a sensitive period of human life; thus, paying attention to the issues and needs of this period is a social necessity [1]. Aging is an inevitable and irreversible process and predictions suggested that by 2050, this population will reach two billion subjects (25% of the world's population) [2]. Common physical problems among the elderly, that occur as a result of certain diseases or the aging process, include a decrease in balance and in the ability to control posture, increased postural fluctuations, and consequently, increased risk of falls, atrophy and muscle weakness, decreased strength, functional dysfunction, and decreased flexibility in these individuals [3].

Furthermore, 30% of 65-year-old elderly experience falls at least once a year, and this rate will increase to 40% with the increased age [4]. Complications that may occur as a result of falls and collapses for the elderly may include some physical disabilities, including bone fractures, immobility, limited mobility, and movement, as well as the occurrence of social and psychological problems such as in-confidence [5]. Falls, directly and indirectly, affect decreased motor function in the elderly [6]. Furthermore, the fear of falling again and avoiding self-imposed activity inevitably affects the active life and physical function of the elderly [5, 6]. One of these physical function components, i.e., impaired with age is muscle strength (Sarcopenia) [7]. It has been an influential factor in the lives of the elderly; research indicated that muscle strength atrophy generates a significant increase of 25% from the age of 50 to 65 years [8]. Based on previous research, implementing a strength training program is an effective approach to prevent the reduction of strength and muscle volume due to aging, which can promote health and quality of life, as well as increase safety from injuries [9]. In addition to reducing muscle strength and muscle fiber, changes in connective tissue decrease elasticity and flexibility [10]. This alternation increases the consequence of stiffness of the tendon muscle unit and stiffness of the joint tissues, structural changes in the cartilage, ligaments, and tendons, leading to a decrease in the range of motion of the joint [11].

According to studies, there is a direct relationship between the reduced range of joints motion and falling [12]. Moreover, this decreased range in the lower limb elevates the risk of falls, by affecting the dynamic of this limb while walking [13]. These changes due to the aging process are associated with physical dysfunction and a decrease in health status [14]. Decreased health factors related to

physical fitness, mental health, and quality of life are a threatening problem for the health of the elderly, which result in changing the quality of life and increasing their care costs [15]. In medicine, quality of life is more related to the meaning of social desirability. Moreover, this definition is strongly related to physical limitations [16].

Regarding the mentioned problems, a large body of literature aimed to improve the abilities of the elderly (balance, strength, flexibility, risk of falling, walking speed, etc.). Among these, paying attention to the role of exercise and exercise therapy as the non-invasive method, is critical in increasing physical capabilities as well as prevention, delaying, or treating problems caused by the aging process. However, research indicated that in addition to the muscular system, focusing on the nervous system plays a critical role in controlling movement and the pattern of movement and walking, especially in the elderly with limited mobility.

One of the newest sports rehabilitation techniques is the Dynamic Neuromuscular Stability (DNS) approach, which also involves the nervous system in addition to strengthening the muscular system [16]. Changes that occur in the nervous system following the aging process include a reduction in the number and size of neurons, as well as a decline in the conduction velocity of nerve impulses. Reports suggested that aging can play an essential role in reducing the accuracy of individuals in retrieving and monitoring movements. Decreased mental abilities, such as memory and intelligence that occur with aging have also been reported by numerous researchers, which can ultimately adversely affect the motor system of the elderly [18].

In general, DNS exercise can re-stimulate the growth process of the nervous-motor system and improve the disorders of the motor system and motor pattern; i.e., according to describing the chain of nerve growth of a healthy infant motor system [19]. Applying this new training protocol has been expanded and the effect of DNS training to improve balance function, motor function, dynamic postural stability, body structure, lower limb function, and quality of life has been investigated in different populations [20, 21]. However, no study examined the effect of these exercises on the bio-motor function of the elderly. The composition of the current population of the country is the young generation, and they will face old age shortly. Thus, it seems that much more attention and efforts should be made to improve the physical dimensions and quality of life in the elderly. Certainly, designing appropriate healthcare and sports rehabilitation programs per the needs of this group of

society is of significance. Therefore, it is doubly crucial to use and benefit a training method that can actively involve the physical fitness factors, such as strength, flexibility, sense of depth, balance, and agility in an exercise protocol concurrently. Furthermore, they play a role in the control of movement and pattern of movement by involving the nervous system.

This study aimed to investigate the effects of DNS exercises, to strengthen the nervous and muscular systems, concerning improving motor function, risk of falls, lower limb strength, flexibility, and finally the quality of life of the elderly.

## Materials and Methods

This was a quasi-experimental study with pretest-posttest design and applied due to interventional variables (DNS training program). Moreover, the purposive selection of subjects was based on inclusion and exclusion criteria and homogeneity of the individuals. To determine the minimum sample size we used the results of previous studies [22] and statistical software to estimate the sample size  $G * POWER$  with a test power of 0.90 and a reliability of 0.95. Accordingly, at least 13 subjects per research group were estimated to be necessary. Moreover, considering the possible sample loss, 15 subjects were considered to participate per group. The inclusion criteria included the following: male gender, the age of 60-70 years, independence in performing daily tasks, and not using assistive devices, cognitive health, vision, hearing, and voluntary participation in the study. Furthermore, the inability and occurrence of pain during the training protocol and the inability to perform movements, the lack of cooperation, and withdrawal from participation during the research were among the exclusion criteria of the research.

Thirty subjects who were eligible to participate in the study were randomly divided into two groups of control and experimental ( $n=15/\text{group}$ ). After completing the informed consent form to participate in the research, the demographic data form, such as name, age, height, and questions about the history of the disease were provided to those interested in participating in the research. To collect the required information, before and after applying the training protocol, from the Tinetti tests (motor function), 30-second sitting on a chair (lower limb strength), sitting and reaching test (flexibility), TUG test (fall risk), and The SF-36 (Quality of Life) questionnaire was used. Notably, the sampling process and training protocol, due to the spread of the Coronavirus

Disease 2019 (COVID-19), the necessary hygiene and health protocols were observed.

To prevent coronavirus infection, the study subjects were required to wear masks and gloves during exercise. Only 3 subjects per hour participated in the study.

The present study was approved by the Ethics Committee of the Faculty of Physical Education and Sports Sciences, University of Tehran (Code: IR.UT.SPORT.REC.1399.042).

### The following measurement tools and methods were implemented in the current study:

**Tinetti test (motor function):** This test assesses a subject's balance and gait, i.e., 9 items for balance and 7 items for walking. The maximum score of this test equals 28. A score of  $<18$  reflects poor motor performance. A score of 19-23 falls in the medium-risk range, and finally, a score  $>24$  indicates good performance. A validity of 0.77-0.82 and reliability of 0.84 have been confirmed by Canbek et al. for this scale [23].

**The 30-second sitting on a chair (lower limb strength) test:** To perform this test, the subject sits on a chair with his back flat, his legs shoulder-width apart, and his arms clasped in front of his chest. With the sign, the respondent begins to completely get up and returns to a sitting position. The test score is the total number of correct stands in 30 seconds. Jones et al. consider this test as a valid and reliable tool (0.98-0.81) for measuring lower limb strength [24].

**Sitting and reaching test (flexibility):** In this test, the subject is requested to sit and stick his legs stretched out on the flexibility board. During the test, the examiner should gently place one hand on the subject's knees, to ensure that the subject's knees are fully extended. The subject raises the arms forward while the hands are on top of each other. The palm is lowered and gently bent forward along the measuring tape. The mentioned movement is performed by the subjects 3 times. The score of the last attempt is recorded by the tester up to the nearest one centimeter. The validity of 0.74 and reliability of 0.92 have been reported to assess flexibility in elderly men [25].

**Timed Get up & Go test (risk of falling):** The TUG test involves sitting on a chair, getting up, and walking up to 3 meters, turning, and sitting on a chair again. The criterion of this test is the time that a subject performs this movement maneuver from the moment of getting up

**Table 1.** Demographic information of the study samples (n=15 per group)

Variables	Groups	Mean±SD	P
Age (y)	Control	64.66±3.84	0.690
	Experimental	65.13±2.29	
Weight (kg)	Control	68.40±1.84	0.181
	Experimental	67.46±1.88	
Height (cm)	Control	165.20±4.47	0.518
	Experimental	166.26±4.44	

from the chair to sitting down again with a stopwatch. The validity and reliability of this test were reported to be very high (ICC=0.97-0.98) [26].

**SF-36 (Quality of Life) Questionnaire:** This scale includes 36 items in 8 subscales, including physical function, role limitation due to physical problems, physical pain, general health, role limitation due to emotional problems, social function, vitality, and emotional welfare. The score of each item ranges between 0 and 100; the score of each subscale is obtained by calculating the average score of the questions of that subscale. The validity of this test was calculated as 0.91 and its reliability ranged between 0.90 and 0.93 [27].

**Exercise protocol:** Basic DNS treatment techniques include general core stability training, agonist and antagonist muscles in limb movement, limb movement to move forward and support, attention to the stability of each part of the motor chain, stabilization training, and breathing pattern [28]. DNS training protocol was conducted in three 45-minute weekly sessions for 6 weeks in the experimental group (Figure 1). These exercises have several models and different levels of training [19]. The training protocol of the experimental group included warm-up exercises (5 minutes), DNS exercises with respiratory correction (40 minutes), and cool-down exercises (5 minutes). The 40 minutes are divided into four 10-minute sections that cover the main movements. According to the DNS approach [19], the main movements with different levels include diaphragmatic breathing (6 levels), lying on your back 90-90 (21 levels), lying on your stomach (9 levels), rolling (20 levels), side-lying (11 levels), oblique sit (11 levels), tripod (13 levels), kneeling (11 levels), as well as squat and get up (9 levels). The first week of training was devoted to training and practicing basic DNS movements. Each week, compared to the previous week, some movement complexity was added. To increase the effectiveness of the exercises during the training period, the overload principle of in-

creasing the number of repetitions and seconds and the type of training was used.

After collecting the necessary information, the data related to the subjects were analyzed in two sections of descriptive and inferential statistics in SPSS. Descriptive statistics, Analysis of Covariance (ANCOVA), and Paired Samples t-test were used for data analysis at a 95% significance level (P=0.05).

## Results

The study participants' demographic characteristics, including height, weight, and age, as well as the results of the homogeneity of the groups, are described in Table 1. As per Table 1, the Independent Samples t-test results indicated no significant difference between the research groups concerning height, weight, and age (P>0.05); thus, the research groups were homogeneous in all the above cases.

According to Shapiro-Wilk test data, the distribution of all measured data was normal (P>0.05). Therefore, to investigate the effect of exercises on the research variables between the control and experimental groups, ANCOVA at the intergroup level, and the Paired Samples t-test at the intra-group level were used. The ANCOVA results indicated a significant difference between the experimental and control groups in motor function (P=0.001), risk of falling (P=0.004), lower limb strength (P=0.001), flexibility (P=0.005), and the total score of quality of life (P=0.001). Furthermore, by examining the mean posttest scores, the experimental group suggested better performance, increased mean scores of motor performance, strength, flexibility, and quality of life, as well as reduced risk of falls, compared to the control group (Table 2).

To investigate the pretest-posttest differences between the research groups, Paired Samples t-test was separately employed (Table 3). Accordingly, there was

**Table 2.** Results of ANCOVA on the effect of independent and predictive variables at posttest

Variables	Groups	Mean±SD	F	df	P	Eta-Squared
Movement function	Experimental	22.86±1.35	62.325	1	0.001*	0.698
	Control	19.06±1.27				
Risk of falling	Experimental	9.50±1.48	22.454	1	0.004*	0.454
	Control	12.13±1.68				
Lower limb strength	Experimental	15.80±2.14	48.105	1	0.001*	0.640
	Control	11.13±1.35				
Flexibility	Experimental	22.06±2.05	9.152	1	0.005*	0.253
	Control	20.02±1.14				
Quality of life	Experimental	57.7±2.71	140.275	1	0.001*	0.839
	Control	46.22±2.14				

\* P<0.05.

**Table 3.** Difference between the mean scores of the study variables in the pretest and posttest for both groups

Variables	Experimental Group			Control Group		
	Mean±SD		P	Mean±SD		P
	Pretest	Posttest		Pretest	Posttest	
Movement function	18.93±1.35	22.86±1.35	0.001*	18.80±1.26	19.06±1.27	0.628
Risk of falling	12.46±1.84	9.50±1.48	0.004*	12.73±1.86	12.13±1.68	0.167
Lower limb strength	10.86±1.68	15.80±2.14	0.001*	10.53±1.40	11.13±1.35	0.209
Flexibility	19.66±1.54	22.06±2.05	0.011*	19.80±1.47	20.02±1.14	0.550

\* P<0.05

**Table 4.** Difference between the mean scores of the study variables in the pretest and posttest for both groups

Variables	Experimental Group			Control Group		
	Mean±SD		P	Mean±SD		P
	Pretest	Posttest		Pretest	Posttest	
General Health	43.66±6.93	57.33±6.87	0.001*	43.33±7.26	44.86±7.11	0.509
Physical Functioning	48.20±7.33	57.93±6.94	0.001*	48±7.02	49±7.12	0.754
Role limitations (physical)	48.80±6.51	59.20±7.52	0.001*	48.66±7.43	49.46±7.65	0.726
Role limitations (emotional)	43.26±10.18	59.93±6.43	0.001*	43.13±7.36	43.73±7.36	0.842
Bodily Pain	43.13±7.36	54.73±7.02	0.001*	46.60±5.39	48±5.11	0.552
Social Functioning	47±9.02	57.13±4.24	0.001*	48±9.78	47.33±8.42	0.852
Energy/vitality	42±8.61	58.20±6.52	0.001*	42.33±9.97	43.26±6.71	0.763
Mental Health	42.80±8.12	58±8.26	0.001*	43.60±5.65	44.13±4.34	0.814
Total	44.85±3.01	57.07±2.71	0.001*	45.45±1.93	46.22±2.14	0.289

\* P<0.05



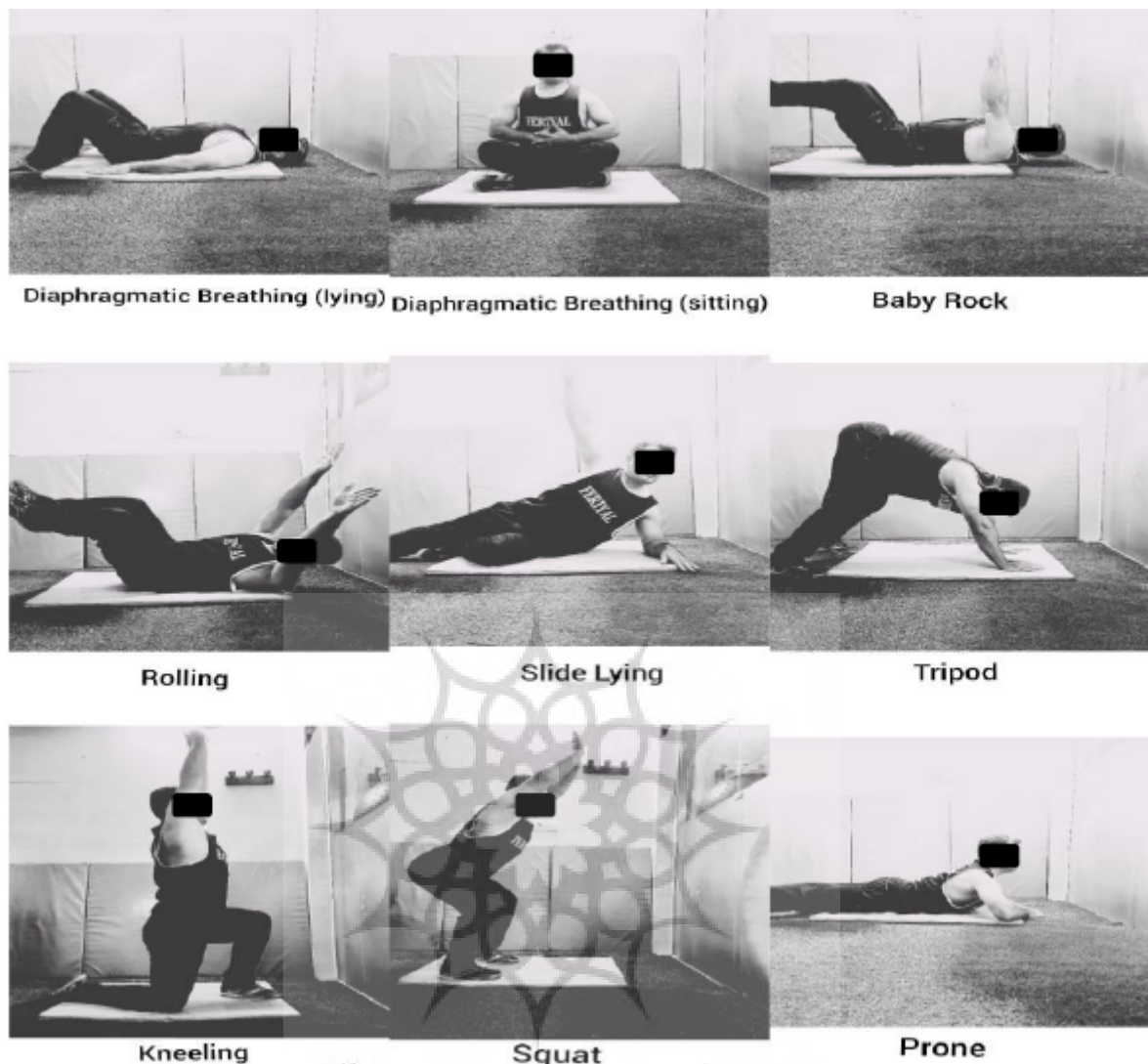


Figure 1. Starting positions of DNS training protocol

a significant difference between pretest and posttest values in motor function, lower limb strength, fall risk ( $P < 0.05$ ) in the group that performed the DNS exercises for 6 weeks; however, no significant difference was observed in the control group ( $P > 0.05$ ) (Table 3). Additionally, the Paired Samples t-test results presented in Table 4 for the quality of life variable in the experimental group revealed a significant difference between pretest and posttest values in general health, physical function, restriction on performing role due to physical and emotional reasons, body pain, social function, energy/vitality, mental health, and the total score of the quality of life questionnaire ( $P < 0.05$ ); however, there was no significant difference between pretest and posttest phases in the control group ( $P > 0.05$ ).

### Discussion

The present study investigated the effects of 6 weeks of DNS training on performance factors (Tinetti, lower limb strength, flexibility, & risk of falls), and quality of life in the elderly. The obtained results revealed a significant difference between the control and exercise groups after exercise intervention (DNS) on motor function, lower limb strength, flexibility, risk of falls, and quality of life. The collected data highlighted the importance of DNS exercise on the quality of life among the elderly. Various exercises have been performed on the elderly to improve the quality of life, reduce the risk of falls, and improve physical function factors, outlining the significance of physical fitness characteristics in the elderly. Dunsky investigated the effects of balance and coordination exercises on the quality of life of the elderly. The related results revealed that this program

provides significant progress in controlling static and dynamic balance in the elderly; subsequently, it presents a positive effect on their quality of life [29]. Gomeñuka et al. argued that walking exercises improve quality of life and motor function in the elderly [30]. Kanda et al. documented the effect of low-intensity exercise on elderly performance [31]. Oliveira et al. stated that Pilates exercises improve quality of life and reduce the risk of falls in the elderly [32]. Vafaenasab et al. signified that lower extremity resistance exercises cause positive changes to improve lower limb muscle strength and improve walking speed in the elderly [33].

With the onset of old age, changes occur in the function of musculoskeletal systems, as well as metabolic and physiological systems, that are involved in function [34]. Multiple age-related changes that occur in the musculoskeletal system are due to a lack of regular physical activity. Consequently, such a condition causes muscle atrophy, weakness, and dysfunction, also increases the risk of falls, leading to disabling fractures in the elderly. In this regard, various exercises have been performed on the elderly to improve and enhance their level of physical fitness. Subsequently, they outlined the impact of regular exercise on this group of society as affected. The current study results also demonstrated that 6 weeks of DNS training positively and significantly impacted motor function and quality of life in the elderly. A sports rehabilitation technique, called DNS, founded by Kular (2013), has been studied by researchers concerning functional rehabilitation [21, 35, 36]. The DNS method explains the high muscle interaction and the appropriate muscle recruitment to stabilize the dynamics of the spine. By stimulating the process of the nervous development of the human locomotor system; also by modeling the conversion of neonatal reflexes into complementary movements, these exercises prevent the progression of the disease. Moreover, they restore proper physical function to individuals with weakness and movement disorders [19].

Dynamic neuromuscular stabilization involves the precise activation of the main muscles of the spine; it forms the integrated spinal stabilization system and includes the flexors and extensors of the neck and diaphragm, the transverse abdominal muscles, the multifidus, and the pelvic floor. The concept of DNS is derived from the principles of growth kinesiology and determines the central movement patterns which exist inherently [19, 37, 38]. Exercises (DNS) planned in the present study were important in improving neuromuscular coordination based on a wide range of strength, range of motion, and increased flexibility [20]. A characteristic of DNS

exercises is to establish communication and coordination between all trunk and thigh muscles to control the healthy position of the spine. The stabilizing muscles of the pelvis and thigh are responsible for maintaining the correct alignment of the lower limbs while performing dynamic movements [39].

The provided training in the study improved lower limb strength, range of motion, flexibility, and performance in the explored elderly. This is due to the presence of movements, such as squats, extensions, and flexions of the knees, thighs, and legs in different directions, and different planes of movement, as well as various exercises on the limbs, trunk, and the use of Thera band, and weight. The possible mechanisms of impact of the training protocol on the strength of the lower limbs in the present study included the strengthening of weakened muscles, such as the abdominal muscles and the large and middle serine muscles in the posterior part. In other words, by improving the strength of the lower muscles, the risk of falls is reduced in the elderly; subsequently, it reduces injuries in this group. As a result, reduced injuries and increased physical fitness improved health, increased self-confidence, and quality of life in this population. Concerning the mentioned cases, DNS training is probably important. This is because in old age, most of the systems and organs of the body will malfunction physiologically and functionally; therefore, osteoporosis occurs in case of inactivity and the lack of exercise, muscle weakness, and the reduced joint function, and all of these make limit the activity and movement. Using these exercises in rehabilitation has been recently welcomed and performed on various other communities with the aim of improving walking function, promoting muscle strength, increasing balance, and improving quality of life [19, 35, 36]. The positive results of this research encouraged researchers about the objectives of the present study to examine the effectiveness of these exercises among the elderly.

Furthermore, in the process of treatment and care of the elderly, attention should be paid to the factors affecting their quality of life. Care and treatment strategies are beneficial when improving the quality of life in the elderly [40]. In other words, conducting a physical activity, such as dynamic neuromuscular stability exercises is considered a pastime for individuals, i.e., associated with happiness in the elderly. Additionally, the physiological and biochemical effects on the mental and emotional state of individuals influence their quality of life [41]. Paying attention to the importance of regular physical activity can strengthen the body and soul in various dimensions; thus, increase the general health

of the body. Numerous personal, physical, mental, and emotional characteristics of the elderly have undergone extensive changes as a result of the aging process, i.e., affected by physical activity. Physical activity postpones the disabilities caused by aging [42]. Performing these exercises is crucial to respect the performance of the elderly, due to their characteristics. Furthermore, performing various movements, different training goals, the results of the study in improving flexibility, increasing muscle strength, range of motion, and reducing the risk of falls, and the importance of strengthening these factors in the elderly.

## Conclusion

The current research findings indicated a significant improvement in the impact of Dynamic Neuromuscular Stability (DNS) exercises on performance factors (Tinetti, lower limb strength, flexibility, fall risk) and quality of life in the elderly. Therefore, it is recommended to use the provided training protocol to prevent and rehabilitate, increase the level of physical fitness, reduce the risk of falls, and increase the quality of life. Furthermore, sports professionals, coaches, and individuals who work with the elderly can benefit from the results of research in advancing the goals for the improvement of the life quality of the elderly.

However, it is impossible to generalize the research findings with certainty. A reason for this is the novelty of the research topic and the lack of research similar to applying the DNS training protocol in the elderly. The sample size, due to its low level, was also among the study limitations. This study was restricted to one gender, as it was conducted on elderly men in Qom City, Iran; accordingly, the collected results cannot be generalized to all elderly communities. However, implementing DNS exercises on motor function in this study can provide a starting point for its use in the rehabilitation of the elderly, as well as a suitable scientific basis for future research. The limitations in this study include the lack of study of issues related to the daily activities, lifestyle, eating habits, diet, mental status, and unavailability of female subjects to be compared with the elderly men. The small sample size should also be noted, i.e., caused by the COVID-19 pandemic. Due to the high importance of the performance factors (Tinetti, lower limb strength, flexibility, fall risk) and quality of life of the elderly, and the significant effect of DNS exercises on the elderly, it is suggested to examine these exercises on the larger communities (elderly), among both genders, and compare their results with those of the present study. It is also suggested to perform the DNS exercises of the

present study with other treatments on the elderly, and compare the obtained data by studies.

## Ethical Considerations

### Compliance with ethical guidelines

This research was approved by the Ethics Committee of the Faculty of Physical Education and Sports Sciences, University of Tehran (Code: IR.UT.SPORT.REC.1399.042). The subjects were allowed to discontinue cooperating with the researcher as desired. Moreover, the principle of confidentiality was observed regarding all information of individuals.

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### Authors' contributions

Conceptualization and supervision: Yousef Moghadas Tabrizi; Methodology: All authors; Investigation, writing-original draft, writing – review & editing: All authors; Data collection and Data analysis: Mohammad Hani Mansori; Funding acquisition and Resources: All authors.

### Conflict of interest

The authors declared no conflict of interest.

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