

Research Paper



The Effect of Head and Neck Stabilization Exercises on Dynamic Balance in the Elderly With Forward Head Posture

Shahram Irani¹, Maryam Abbaszadeh-Amirdehi^{2*}, Seyed Reza Hosseini³, Shima Sum⁴, Hossein Matlabi^{5,6}, Setareh Mirasi⁷

1. Department of Community Medicine, School of Medicine, Babol University of Medical Sciences, Babol, Iran.
2. Mobility Impairment Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran.
3. Social Determinants of Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran.
4. Department of Public Health and Gerontology, Faculty of Health, Babol University of Medical Sciences, Babol, Iran.
5. Department of Geriatric Health, Tabriz University of Medical Sciences, Tabriz, Iran.
6. Research Center for Integrative Medicine in Aging, Aging Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran.
7. Department of Physiotherapy, School of Rehabilitation, Babol University of Medical Sciences, Babol, Iran.



Citation Irani Sh, Abbaszadeh-Amirdehi M, Hosseini SR, Sum Sh, Matlabi H, Mirasi S. The Effect of Head and Neck Stabilization Exercises on Dynamic Balance in the Elderly With Forward Head Posture. Journal of Modern Rehabilitation. 2022; 16(1):9-16. <https://doi.org/10.18502/jmr.v16i1.8556>

<https://doi.org/10.18502/jmr.v16i1.8556>

Article info:

Received: 05 Apr 2020

Accepted: 14 Apr 2021

Available Online: 01 Jan 2022

ABSTRACT

Introduction: This study aimed to investigate the effect of head and neck stabilization exercises on improving balance in older adults with forward head posture.

Materials and Methods: Thirty elderly participants with forward head posture and Mean±SD age of 65.7±5.2 years were examined. The forward head posture was measured by plumb line and craniocervical angle. Elderly balance was evaluated before and after 8 weeks of head and neck stabilization exercises with Timed Up and Go (TUG) and Functional Reach (FR) tests. The paired t-test was used to examine the changes that occurred after the intervention.

Results: The results showed that head and neck stabilization exercises in the elderly significantly changed TUG test (8.3 s before the intervention, 7.8 s after the intervention; P=0.03) and FR test (23.4 cm before the intervention, 24.7 cm after the intervention; P=0.01) omitted. No significant statistical changes were observed in the amount of the craniocervical angle after the intervention.

Conclusion: Based on the study results, performing the head and neck stabilization exercises did not cause significant changes in the craniocervical angle but improved the dynamic balance of the elderly.

Keywords:

Elderly, Forward head posture, Balance, Craniocervical angle, Stabilization exercises

* Corresponding Author:

Maryam Abbaszadeh-Amirdehi, PhD.

Address: Mobility Impairment Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran.

Tel: +98 (911) 1158723

E-mail: abbaszadeh_m@alumnus.tums.ac.ir



1. Introduction

Aging can be defined as a complex dynamic process characterized by a progressive decline of physiological function [1-3]. Aging changes occur in all organs of the body and affect the functioning of all body systems [4]. The specific changes of the musculoskeletal system during the aging process led to deviations from the standard alignment, which is called postural malalignments. Different body segments such as head, neck, shoulders, thoracic and lumbar spine may be affected by this malalignment [5-8].

Forward Head Posture (FHP) is one of the most common postural malalignments in the sagittal view in the elderly [9]. This condition is part of the upper crossed syndrome, functional impairment of the muscular system [10]. In this disorder, the cervical spine is flattened. Also, a backward bending in the upper cervical region, coupled with a forward translation of the lower cervical region, is seen [11, 12]. This situation causes an anterior shift in body weight. This shift changes the relationship between the line of gravity and the level of foot rest. It ultimately reduces the balance and increases the incidence of falling in the elderly [13, 14]. In response, the cervical muscles, which have a high density of muscle spindles that play an essential role in providing deep neck sensory information, go through some adaptive change in response to malalignment of the head and neck [15]. These changes include shortening of cervical spine extensors and lengthening of the intrinsic cervical spine flexors [16]. A change in the function of these muscles due to the inappropriate state of the head adversely affects the movement and balance control, which leads to balance disturbance and a higher risk of falling [14, 17].

Therapeutic exercises and postural training are generally used to improve balance [7, 18-20]. Several studies have investigated the effects of different exercise regimes for addressing FHP [6, 21-25]. Since FHP creates a specific muscle imbalance pattern that affects proprioception and balance, stabilization exercises activate and strengthen deep cervical flexor muscles that help restore the normal muscle recalling pattern, proprioception, and balance. This study aims to evaluate the effects of head and neck stabilization exercises on improving balance in the elderly with FHP.

2. Materials and Methods

Study subjects

In this clinical trial study, 30 participants more than 60 years old with FHP took part after signing the consent form. If any of the elderly has a history of spinal surgery, neck injury, acute and repetitive pain in the neck and back, spinal anomalies, lack of autonomy in daily tasks, vision problems, dizziness, balance disorders, chronic headache, temporomandibular joint dysfunction, rheumatic disease, orthopedic and neurological problems, depression, anxiety and or other psychiatric disorders were excluded from the study. The sample size was determined 30 according to the G*Power software version 3.1.7 for statistical power of 80%, confidence interval of 95%, and medium effect size. This study was supervised by the Ethics Committee of the Babol University of Medical Sciences (MUBABOL, HRI.REC.1395.35).

Head postural assessment

First, all participants were evaluated in a standing position with a plumb line suspended from the ceiling to observe the head's position related to the vertical line and ensure that they had FHP. With normal head posture, a vertical plumb line passes through the mid-shoulder and external auditory meatus, but in forward head posture, the head lies anterior to this vertical line. Then, the exact angle of the FHP was determined using craniocervical angle. To measure the craniocervical angle, the participants were asked to stand in a comfortable position while moving their weights evenly to the feet and look at a spot on the wall. The spinous process of the seventh cervical vertebra and the tragus of each person's ear were marked on their skin by a label. Next, the participants were shot in profile by a digital camera (Olympus VG-160, China) set on a tripod at a distance of 1.5 m from the subjects' shoulder level. After that, the craniocervical angle was measured on the taken photographs by calculating the angle of the horizontal line passing through the seventh cervical vertebra and the line passing through the tragus to the seventh cervical vertebra (Figure 1) [8, 26]. The craniocervical angles smaller than 48-50 degrees indicate the forward head posture. The greater forward head posture has the smaller craniocervical angles [9].

Dynamic balance assessment

To evaluate the dynamic balance of each participant, we used the Timed Up and Go (TUG) and Functional Reach (FR) tests. In the TUG test, the subject was asked to sit on a chair and put his or her hands on an armrest.

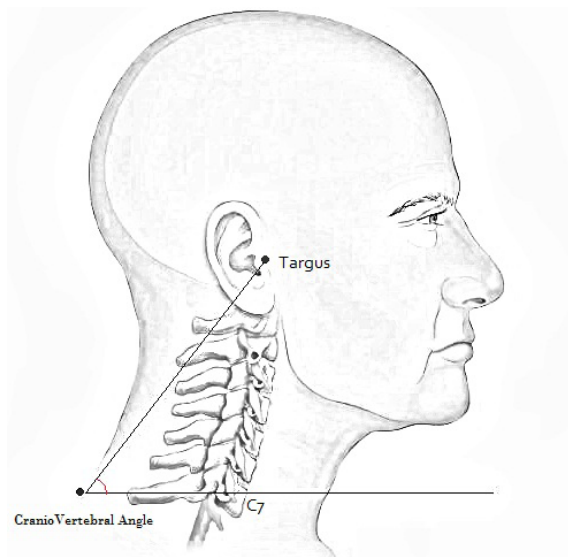


Figure 1. Craniovertebral angle measurement **JMR**

After the “start” announcement, the subject should rise and walk up a 3-m distance along the straight line marked on the floor, then rotate, go back, and sit in the chair again. The duration of this test is recorded in seconds [27].

To perform the FR test, the subject is asked to stand next to but not touch a wall and elevate the upper extremity closer to the wall to 90 degrees of shoulder flexion with a closed fist. The examiner records the starting position at the third metacarpal head on the yardstick mounted on the wall. The starting position at the third metacarpal head is highlighted on the installed measuring tape. Next, the subject is asked to reach forward as far as possible

without taking a step and losing his or her balance. After reaching the maximum possible displacement, the new position of the third metacarpal head was re-recorded (Figure 2). The score was determined by calculating the difference between the two positions in cm [28].

Intervention

Maintaining the head and neck’s neutral position during daily living activities and stabilization exercises were taught to the elderly three times a week for 8 weeks (a total of 24 sessions). Education and exercises were conducted under the supervision of a physiotherapist at an Elderly Health Center. To perform the stabilization exercises, we instructed four training exercises with 12 repetitions, including strengthening of the neck deep flexors, stretching of the neck extensors, strengthening of shoulder retractors, and stretching the pectoral muscles [12, 29, 30].

Statistical analysis

The obtained data were analyzed with the SPSS v. 20 (SPSS Inc, Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine the normal distribution of the data ($P > 0.05$). The paired t-test was performed to evaluate the changes of the variables before and after the intervention. The confidence interval was set at 0.95, and statistical significance was ≤ 0.05 .

3. Results

Thirty participants were included in this study. The demographic characteristics of the individuals are pre-

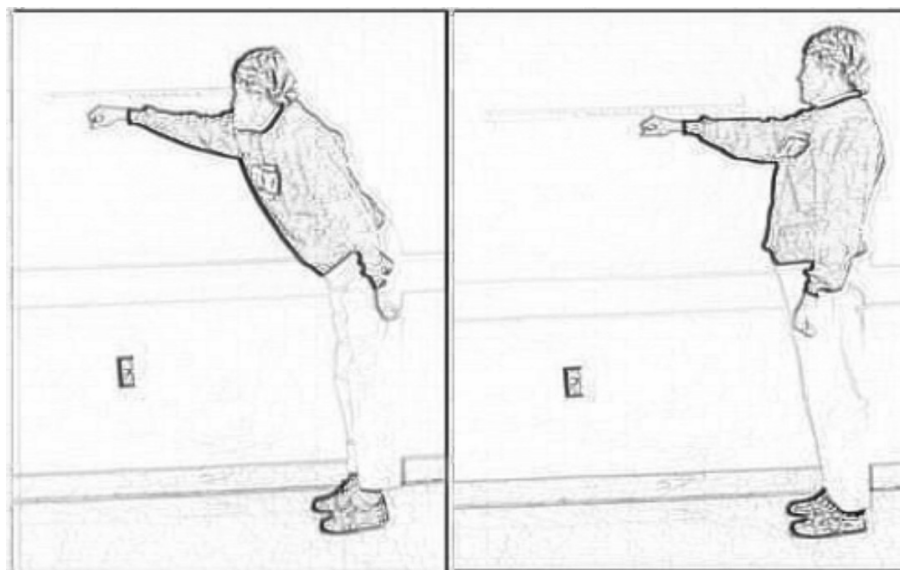


Figure 2. Functional Reach Test

Table 1. Demographic characteristics of the participants (n=30)

Variables		No.	Mean±SD	Min	Max
Age (y)			65.7±5.2	60	75
Height (cm)			157.0±7.7	142	176
Weight (kg)			70.8±11.1	47	108
Body mass index (kg/m ²)			28.9±4.7	18	40
Gender	Female	25	-	-	-
	Male	5	-	-	-

JMR

sented in Table 1. The frequency distribution of the variables showed that all had a normal distribution ($P>0.05$). The paired t-test results before and after the intervention showed significant statistical in TUG and FR test results. The mean change in craniocervical angle after the stabilization exercises has not demonstrated a statistically significant difference (Table 2). Minimal detectable change and mean difference were calculated to determine whether the change measurement of the variable has improved clinically (Table 2).

4. Discussion

This study demonstrated that head and neck stabilization exercises significantly improved dynamic balance in the elderly with FHP. The mean score of the TUG test significantly decreased with medium effect size, and the FR test mean score increased dramatically with an almost large effect size after the intervention. Although changes in the craniocervical angle were not statistically significant, they are clinically significant. All variables in this study, including the TUG test, FR test, and craniocervical angle, showed clinically significant changes due to their increased value of the mean difference relative to the value of minimal detectable change.

The head and neck area closely contribute to maintaining a person's balance because vision, vestibular, and

proprioception systems play an essential role in the stability of posture and balance. Proprioception is a significant part of the somatosensory system, responsible for providing information for the central nervous system to maintain a good balance. Proprioception afferents are essential in controlling the condition by providing information about the head's position relative to the trunk [31, 32]. The forward head posture by changing the biomechanics of muscles and ligaments caused changes in the muscle length and tension and, consequently, changes in muscle spindle sensitivity and proprioception responses. The altered proprioceptive response leads to different impulses that transmit to the central nervous system and cause disturbances in the central processing of postural balance [31-34]. According to Nummer et al., older adult women with a higher FHP are less likely to have balance [35].

Evidence suggests the positive effects of various exercises on improving the FHP and reducing the craniocervical angle in adults [6, 12, 36-41]. Benedetti et al. demonstrated improved FHP using occiput-to-wall distance after flexibility and strengthening exercise in older adults [42]. According to Abdolazadeh et al., four weeks of postural corrective exercise improves postural alignment related to FHP, confirmed by measuring craniocervical angle on female students [43]. Several studies have shown that spinal stability exercises increase postural stability and improve balance [44, 45]. However, our

Table 2. Comparing the variables changes after the intervention

Variables	Mean±SD		P	Effect Size (Cohen's d)	Mean Difference	Minimal Detectable Change
	Before Intervention	After Intervention				
Time Up and Go test (s)	8.3±1.8	7.8±2.2	0.03	0.4	6.2	1.0
Functional Reach test (cm)	23.5±6.6	24.7±7.8	0.01	0.5	4.9	3.7
Craniocervical angle (degree)	43.0±9.8	45.0±4.2	0.16	0.2	5.0	3.8

Cohen's d 0-0.2 small, 0.2-0.5 medium, 0.5-0.8 large, ≥0.8 very large.

JMR

study did not show improvement in forward head posture statistically after stabilization exercise in the elderly, but dynamic balance improved after the intervention.

The goal of stabilization exercises is to re-educate global and local stability simultaneously through modifying motor control. Neck stabilization exercises affect postural control through concurrent contractions of the agonist and antagonist muscles, the suboccipital muscles, the multifidus, and deep neck flexors which are the most important cervical stabilizers. With the activation of local muscles, the global stabilizing muscles of the neck and scapula act synergically to maintain normal function. Consequently, stabilization exercises improve the neck muscles' proprioception by increasing agonist muscles' contractions, improving head and neck reflexes, and increasing the environmental inputs. An improvement in proprioception leads to better balance [33, 46, 47]. Similar to our study, a previous study reported that six weeks of stabilization exercise improved the balance of participants with FHP.

Nevertheless, the authors did not measure the cranio vertebral angle after the intervention. Furthermore, the study's target group was young people [47]. Since the neck muscles have the highest levels of afferent nerves in the motor system and have the most significant impact on the central nervous system concerning motor planning, modifying these muscles can provide appropriate status responses. Even though the changes in muscle length and tension in this study were not considerable enough to significantly improve the head and neck position, it seems that the positive effect of the exercise on the proprioception has produced more satisfactory postural responses and good balance than before the exercise.

5. Conclusion

In the present study, the effect of head and neck stabilization exercises on improving the dynamic balance of the elderly people with the forward head posture showed that although correction of head position and reduction of forward head posture was not statistically significant, stabilization exercises effectively improved dynamic balance of the elderly. Since in the maintenance of the balance, proprioception afferents of muscle spindles play an essential role, and the deep muscles of the neck area are also rich in muscle spindles, it seems that head and neck stabilization exercises improve the function of these sensory receptors and by doing so provide appropriate postural responses in the elderly adults.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the Babol University of Medical Sciences (Code: MUBABOL.HRI.REC.1395.35).

Funding

Research Deputy of Babol University of Medical Sciences financially supported this study (No. 950204).

Authors contributions

Conceptualization and supervision: Maryam Abbaszadeh-Amirdehi; Seyed Reza Hosseini; Methodology: Maryam Abbaszadeh-Amirdehi; Seyed Reza Hosseini; Shima Sum; Investigation, writing – original draft, and writing – review & editing: All authors; Data collection: Shahram Irani; Setareh Mirasi; Data analysis: Maryam Abbaszadeh-Amirdehi; Hossein Matlabi.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

We would like to thank the Research Deputy, Babol University of Medical Sciences that financially supported this study. We would also thank all the participants and elderly health center staff where the samples were gathered.

References

- [1] Colloca G, Di Capua B, Bellieni A, Fusco D, Ciciarello F, Tagliaferri L, et al. Biological and functional biomarkers of aging: Definition, characteristics, and how they can impact everyday cancer treatment. *Current Oncology Reports*. 2020; 22(11):115. [DOI:10.1007/s11912-020-00977-w] [PMID] [PMCID]
- [2] Dziechciaż M, Filip R. Biological psychological and social determinants of old age: Bio-psycho-social aspects of human aging. *Annals of Agricultural and Environmental Medicine: AAEM*. 2014; 21(4):835-8. [DOI:10.5604/12321966.1129943] [PMID]
- [3] van Beek JH, Kirkwood TB, Bassingthwaite JB. Understanding the physiology of the ageing individual: Computational modelling of changes in metabolism and endurance. *Interface Focus*. 2016; 6(2):20150079. [DOI:10.1098/rsfs.2015.0079] [PMID] [PMCID]

- [4] Kenig J. Oncogeriatrics (part 2). Normal and pathological ageing. *Nowotwory Journal of Oncology*. 2019; 69(3-4):146-9. [DOI:10.5603/NJO.2019.0027]
- [5] Bansal S, Katzman WB, Giangregorio LM. Exercise for improving age-related hyperkyphotic posture: A systematic review. *Archives of Physical Medicine and Rehabilitation*. 2014; 95(1):129-40. [DOI:10.1016/j.apmr.2013.06.022] [PMID] [PMCID]
- [6] Bayattork M, Sköld MB, Sundstrup E, Andersen LL. Exercise interventions to improve postural malalignments in head, neck, and trunk among adolescents, adults, and older people: Systematic review of randomized controlled trials. *Journal of Exercise Rehabilitation*. 2020; 16(1):36-48. [DOI:10.12965/jer.2040034.017] [PMID] [PMCID]
- [7] Jang HJ, Hughes LC, Oh DW, Kim SY. Effects of corrective exercise for thoracic hyperkyphosis on posture, balance, and well-being in older women: A double-blind, group-matched design. *Journal of Geriatric Physical Therapy*. 2019; 42(3):E17-27. [PMID]
- [8] Abbaszadeh-Amirdehi M, Hosseini SR, Irani S, Mirasi S, Sam S. Influence of body positions on craniocervical angle in the elderly people with forward head posture: A pilot study. *Journal of Modern Rehabilitation*. 2019; 12(2):85-8. <https://jmr.tums.ac.ir/index.php/jmr/article/view/160>
- [9] Shaghayegh Fard B, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. *European Spine Journal*. 2016; 25(11):3577-82. [DOI:10.1007/s00586-015-4254-x] [PMID]
- [10] Seidi F, Bayattork M, Minoonejad H, Andersen LL, Page P. Comprehensive corrective exercise program improves alignment, muscle activation and movement pattern of men with upper crossed syndrome: Randomized controlled trial. *Scientific Reports*. 2020; 10(1):20688. [DOI:10.1038/s41598-020-77571-4] [PMID] [PMCID]
- [11] Cheshomi S, Alizadeh MH, Barati AH, Akochakian M. [The effect of six weeks corrective exercise on upper-crossed syndrome of overhead athletes (Persian)]. *Journal of Applied Exercise Physiology*. 2018; 14(27):153-66. http://www.asp.journals.umz.ac.ir/article_1803.html?lang=en
- [12] Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. *Journal of Manual & Manipulative Therapy*. 2005; 13(3):163-76. [DOI:10.1179/106698105790824888]
- [13] Osoba MY, Rao AK, Agrawal SK, Lalwani AK. Balance and gait in the elderly: A contemporary review. *Laryngoscope Investigative Otolaryngology*. 2019; 4(1):143-53. [DOI:10.1002/lio2.252] [PMID] [PMCID]
- [14] Lee JH. Effects of forward head posture on static and dynamic balance control. *Journal of Physical Therapy Science*. 2016; 28(1):274-7. [DOI:10.1589/jpts.28.274] [PMID] [PMCID]
- [15] Smith DL, Haug MJ, Walsh MS. The effect of posture on neck proprioception and head/neck stabilization in asymptomatic participants. *The Journal of the Canadian Chiropractic Association*. 2019; 63(2):100-10. [PMID]
- [16] Goodarzi F, Rahnama L, Karimi N, Baghi R, Jaberzadeh S. The effects of forward head posture on neck extensor muscle thickness: An ultrasonographic study. *Journal of Manipulative and Physiological Therapeutics*. 2018; 41(1):34-41. [DOI:10.1016/j.jmpt.2017.07.012] [PMID]
- [17] Silva AG, Johnson MI. Does forward head posture affect postural control in human healthy volunteers? *Gait & Posture*. 2013; 38(2):352-3. [DOI:10.1016/j.gaitpost.2012.11.014] [PMID]
- [18] Choi W, Lee S. Ground kayak paddling exercise improves postural balance, muscle performance, and cognitive function in older adults with mild cognitive impairment: A randomized controlled trial. *Medical Science Monitor*. 2018; 24:3909-15. [DOI:10.12659/MSM.908248] [PMID] [PMCID]
- [19] Mesquita LS, de Carvalho FT, Freire LS, Neto OP, Zangaro RA. Effects of two exercise protocols on postural balance of elderly women: A randomized controlled trial. *BMC Geriatr*. 2015; 15:61. [DOI:10.1186/s12877-015-0059-3] [PMID] [PMCID]
- [20] Sherrington C, Fairhall NJ, Wallbank GK, Tiedemann A, Michaleff ZA, Howard K, et al. Exercise for preventing falls in older people living in the community. *The Cochrane Database of Systematic Reviews*. 2019; 1(1):CD012424. [DOI:10.1002/14651858.CD012424.pub2] [PMID] [PMCID]
- [21] Safwat YM, Wade AN, Lasheen YR, Kamel RM. Influence of scapular stabilization exercises on asymptomatic forward head posture; A randomized controlled trial. *Indian Journal of Public Health Research & Development*. 2019; 10(12):1410-5. [DOI:10.37506/v10/i12/2019/ijphrd/192406]
- [22] Sohrabi S, Rahimi M, Babaei-Mobarakeh M, Piri H. The effect of eight weeks of Iyengar yoga with an emphasis on spine and shoulder exercises on the upper cross syndrome in middle-aged women. *Journal of Modern Rehabilitation*. 2020; 14(3):159-68. <https://jmr.tums.ac.ir/index.php/jmr/article/view/319>
- [23] Gurudut P, Welling A, Chodankar A. Effect of self-care exercises in forward head posture on craniocervical angle and craniocervical flexion endurance: A pilot study. *Indian Journal of Physical Therapy and Research*. 2020; 2(1):25-30. [DOI:10.4103/ijptr.ijptr_48_19]
- [24] Sikka I, Chawla C, Seth S, Alghadir AH, Khan M. Effects of deep cervical flexor training on forward head posture, neck pain, and functional status in adolescents using computer regularly. *BioMed Research International*. 2020; 2020:8327565. [DOI:10.1155/2020/8327565] [PMID] [PMCID]
- [25] Cho J, Lee E, Lee S. Upper cervical and upper thoracic spine mobilization versus deep cervical flexors exercise in individuals with forward head posture: A randomized clinical trial investigating their effectiveness. *Journal of Back and Musculoskeletal Rehabilitation*. 2019; 32(4):595-602. [DOI:10.3233/BMR-181228] [PMID]
- [26] Abbaszadeh-Amirdehi M, Hosseini S, Sam S, Irani S, Mirasi S. evaluation of head position using craniocervical angle in two sitting and standing positions in the elderly. *Journal of Babol University of Medical Sciences*. 2020; 22(1):31-8. <http://jbums.org/article-1-8802-en.html>
- [27] Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Physical Therapy*. 2000; 80(9):896-903. [DOI:10.1093/ptj/80.9.896] [PMID]
- [28] Wallmann HW. Comparison of elderly nonfallers and fallers on performance measures of functional reach, sensory

- organization, and limits of stability. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*. 2001; 56(9):M580-3. [DOI:10.1093/gerona/56.9.M580] [PMID]
- [29] Kim KH, Kim SG, Hwangbo G. The effects of horse-riding simulator exercise and Kendall exercise on the forward head posture. *Journal of Physical Therapy Science*. 2015; 27(4):1125-7. [DOI:10.1589/jpts.27.1125] [PMID] [PMCID]
- [30] Fathollahnejad K, Letafatkar A, Hadadnezhad M. The effect of manual therapy and stabilizing exercises on forward head and rounded shoulder postures: A six-week intervention with a one-month follow-up study. *BMC Musculoskeletal Disord*. 2019; 20(1):86. [DOI:10.1186/s12891-019-2438-y] [PMID] [PMCID]
- [31] Bove M, Courtine G, Schieppati M. Neck muscle vibration and spatial orientation during stepping in place in humans. *Journal of Neurophysiology*. 2002; 88(5):2232-41. [DOI:10.1152/jn.00198.2002] [PMID]
- [32] Courtine G, Papaxanthis C, Laroche D, Pozzo T. Gait-dependent integration of neck muscle afferent input. *Neuroreport*. 2003; 14(18):2365-8. [DOI:10.1097/00001756-200312190-00015] [PMID]
- [33] Veqar Z, Kumar D. Role of a sensor motor and a cervical stabilization exercise program in the correction of forward head posture in male visual display unit operators. *Gait & Posture*. 2005; 21(Suppl 1):S135. [DOI:10.1016/S0966-6362(05)80447-3]
- [34] Vuillerme N, Pinsault N, Vaillant J. Postural control during quiet standing following cervical muscular fatigue: Effects of changes in sensory inputs. *Neuroscience Letters*. 2005; 378(3):135-9. [DOI:10.1016/j.neulet.2004.12.024] [PMID]
- [35] Nemmers TM, Miller JW. Factors influencing balance in healthy community-dwelling women age 60 and older. *Journal of Geriatric Physical Therapy*. 2008; 31(3):93-100. [DOI:10.1519/00139143-200831030-00003] [PMID]
- [36] Im B, Kim Y, Chung Y, Hwang S. Effects of scapular stabilization exercise on neck posture and muscle activation in individuals with neck pain and forward head posture. *Journal of Physical Therapy Science*. 2016; 28(3):951-5. [DOI:10.1589/jpts.28.951] [PMID] [PMCID]
- [37] Kang DY. Deep cervical flexor training with a pressure biofeedback unit is an effective method for maintaining neck mobility and muscular endurance in college students with forward head posture. *Journal of Physical Therapy Science*. 2015; 27(10):3207-10. [DOI:10.1589/jpts.27.3207] [PMID] [PMCID]
- [38] Lee SM, Lee CH, O'Sullivan D, Jung JH, Park JJ. Clinical effectiveness of a Pilates treatment for forward head posture. *Journal of Physical Therapy Science*. 2016; 28(7):2009-13. [DOI:10.1589/jpts.28.2009] [PMID] [PMCID]
- [39] Ruivo R, Carita A, Pezarat-Correia P. The effects of training and detraining after an 8-month resistance and stretching training program on forward head and protracted shoulder postures in adolescents: Randomised controlled study. *Manual Therapy*. 2016; 21:76-82. [DOI:10.1016/j.math.2015.05.001] [PMID]
- [40] Cho J, Lee E, Lee S. Upper thoracic spine mobilization and mobility exercise versus upper cervical spine mobilization and stabilization exercise in individuals with forward head posture: A randomized clinical trial. *BMC Musculoskeletal Disorders*. 2017; 18(1):525. [DOI:10.1186/s12891-017-1889-2] [PMID] [PMCID]
- [41] Lee DY, Nam CW, Sung YB, Kim K, Lee HY. Changes in rounded shoulder posture and forward head posture according to exercise methods. *Journal of Physical Therapy Science*. 2017; 29(10):1824-7. [DOI:10.1589/jpts.29.1824] [PMID] [PMCID]
- [42] Benedetti MG, Berti L, Presti C, Frizziero A, Giannini S. Effects of an adapted physical activity program in a group of elderly subjects with flexed posture: Clinical and instrumental assessment. *Journal of Neuroengineering and Rehabilitation*. 2008; 5:32. [DOI:10.1186/1743-0003-5-32] [PMID] [PMCID]
- [43] Abdollahzade Z, Shadmehr A, Malmir K, Ghotbi N. Effects of 4-week postural corrective exercise on correcting forward head posture. *Journal of Modern Rehabilitation*. 2017; 11(2):85-92. <https://jmr.tums.ac.ir/index.php/jmr/article/view/81>
- [44] Kim BB, Lee JH, Jeong HJ, Cynn HS. Effects of suboccipital release with craniocervical flexion exercise on craniocervical alignment and extrinsic cervical muscle activity in subjects with forward head posture. *Journal of Electromyography and Kinesiology*. 2016; 30:31-7. [DOI:10.1016/j.jelekin.2016.05.007] [PMID]
- [45] Sazo-Rodríguez S, Méndez-Rebolledo G, Guzmán-Muñoz E, Rubio-Palma P. The effects of progressive neuromuscular training on postural balance and functionality in elderly patients with knee osteoarthritis: A pilot study. *Journal of Physical Therapy Science*. 2017; 29(7):1229-35. [DOI:10.1589/jpts.29.1229] [PMID] [PMCID]
- [46] Comerford MJ, Mottram SL. Movement and stability dysfunction-contemporary developments. *Manual Therapy*. 2001; 6(1):15-26. [DOI:10.1054/math.2000.0388] [PMID]
- [47] Salehi S, Hedayati R, Bakhtiari A H, sanjari M A, Ghorbani R. [The comparative study of the effect of stabilization exercise and stretching-strengthening exercise on balance parameters in forward head posture patients (Persian)]. *Archives of Rehabilitation*. 2013; 14(1):50-60. <http://rehabilitationj.uswr.ac.ir/article-1-979-en.html>

This Page Intentionally Left Blank