Research Paper: Comparison of Static and Dynamic Postural Stability Between Individuals With and Without Forward Head Posture

Hamed Abbasi[1*], Mohammad Hossein Alizadeh[2], Reza Rajabi[2], Fariba Mohammadi[1]

1. Department of Sport Injuries and Corrective Exercises, Sport Sciences Research Institute, Tehran, Iran.
2. Department of Sport Medicine and Health, Faculty of Physical Education and Sport Sciences, University of Tehran, Iran.

Use your device to scan and read the article online

Citation Abbasi H, Alizadeh MH, Rajabi R, Mohammadi F. Comparison of Static and Dynamic Postural Stability Between Individuals With and Without Forward Head Posture. Physical Treatments. 2020; 10(3):127-134. http://dx.doi.org/10.32598/ptj.10.3.364.3

doi: http://dx.doi.org/10.32598/ptj.10.3.364.3

Article info:
Received: 24 Jun 2019
Accepted: 05 May 2020
Available Online: 01 Jul 2020

Keywords:
Spine, Neck, Postural Control

ABSTRACT

Purpose: The growing popularity of media devices such as smartphones and computers has made humankind to acquire forward head posture increasingly. This study aimed to compare static and dynamic postural stability between people with and without forward head posture.

Methods: 15 male students with normal posture (24±4 years, 173±6 cm and 70±6 kg) and 15 male students with forward head posture (25±3 years, 178±7 cm and 68±5 kg) were selected purposefully according to the Cranio-vertebral angle. Biodex Stability System was evaluated used to measure Static and dynamic postural stability.

Results: The results showed a significant difference between the two groups in dynamic postural stability in both open and closed eyes conditions($P<0.05$), whereas no significant difference was observed in static postural stability in both open and closed eyes conditions ($P>0.05$).

Conclusion: Individuals with forward head posture performed weaker in dynamic postural stability than normal ones, as a result, forward head posture is considered as one of the factors disturbing dynamic postural stability.

*** Corresponding Author:**
Hamed Abbasi, PhD.
Address: *Department of Sport Injuries and Corrective Exercises, Sport Sciences Research Institute, Tehran, Iran.*
Phone: *+98 (938) 88142338*
E-mail: *hamedabbasi26@gmail.com*

Highlights

● Individuals with forward head posture showed significantly weaker dynamic postural stability (more postural sways) than normal ones.

● No significant difference was observed in static postural stability between individuals with and without forward head posture.

Plain Language Summary

The rising use of media devices, such as smartphone and PCs in the era of technology has made us maintain specific postures for long periods, which results in some sort of adaptations accordingly. These adaptations make the body to deviate from normal posture. Sustaining a good posture is a big part of our health. It ensures that the bones are well aligned with the rest of the body, while the tension in the muscles and ligaments is properly distributed. It also keeps the body parts in their correct positions with the least stress. The key to good posture is the position of the spine. Forward head posture is a poor habitual neck posture which is known by moving the head in forward direction in relation to the rest of the body. This posture is increasing in individuals as an outcome of the modern lifestyle. We need a good balance to do everything. Deviating from normal posture can affect the optimum function of the body. Since with forward head posture the body gets out of the line of balance, we aimed to see if the balance control could be affected with the forward head posture; hence, we selected students with normal posture and forward head posture and measured static and dynamic balance and compared the scores of the two groups. The results showed a dysfunction in individuals with forward head posture performing dynamic balance compared to the normal ones.

1. Introduction

Modern life with sitting at a computer, using a smartphone, or otherwise engaging in activities that put the head into a forward position for a long time would round the shoulders and makes the head move forward. Forward Head Posture (FHP) is a poor habitual neck posture that typically includes headaches, stiffness, and neck pain. FHP, as a poor position, has the potential to affect postural stability by altering the function and role of the neck area [1]. Maintaining an upright posture requires extremely fine sensorimotor control. Even a slight dysfunction could easily provide identifiable effects. The human body uses data from the proprioceptive, vestibular, and visual receptors to control posture [2]. Gathering information from the available sources enables the body to make the necessary adjustments through movement strategies in favor of postural stability [2].

Proprioceptive afferent from neck muscles significantly affects postural control. In a desirable alignment of posture, the line of gravity passes through the center or near the center of the joints. Accordingly, it leads to the least amount of pressure and effort to maintain or restore postural stability [2]. However, in FHP, the head moves forward from the plumb line on the sagittal plane. In FHP, the Center of Gravity (COG) of the head shifts in the anterosuperior direction, increasing the load on the neck. Subsequently, it generates the dysfunction of the musculoskeletal, neuronal, and vascular systems [3]. FHP causes muscle imbalance and the constant and irregular contraction of the suboccipital, neck, and shoulder muscles. As a result, FHP has the potential to fall in the Kinesio pathological model; eventually, it impairs proprioceptive information from neck muscles and contributes to postural control disturbance.

Data on the effect of FHP on static and dynamic postural stability are scarce. Lee et al. (2016) aimed to determine the effects of FHP on static and dynamic balance control. They concluded that total sway distances were significantly higher in the FHP group, compared to the controls. Results of dynamic balance control did not significantly differ between the research groups [3]. Hyong et al. (2012) examined the effect of FHP on the range of motion of the ankle joint and static balance. They reported that FHP did not affect individuals' static balance [4]. Kang et al. (2012) investigated the balance of individuals who sit at the computer for a long time; they concluded that this abnormality may contribute to some disturbance in the balance of healthy adults [5]. Lee et al. (2014) explored the effect of FHP on proprioception by determining the cervical position-reposition error. There were significant differences in the error value of the joint position sense (cervical flexion, extension, & rotation) between the FHP and control groups. Besides, there was an inverse correlation between the craniovertebral angle and the error value of the joint position sense. This result implies that the change in the muscle length, caused by FHP, decreases the joint position sense. Additionally, proprioception is aggravated as FHP becomes more severe [6]. The later suggests that proprioception impairment could affect postural stability. Literature reveals that studies that examined the contribution of the FHP to postural stability are limited. However, FHP is becoming increasingly prevalent in modern life. This is because we particularly spend long hours on computers and smartphones. Identifying the effects of this posture could increase insight regarding postural stability. Therefore, this study aimed to compare the postural stability between students with and without FHP using the Biodex Balance System (BBS).

2. Materials and Methods

This was a causal-comparative study. In the present study, we compared the postural stability between students with FHP and those with No Forward Head Posture (NFHP). The statistical population of this study consisted of students of the dormitory of Tehran University. Through convenience sampling, we purposively selected 15 individuals with FHP and 15 individuals without FHP.

FHP was assessed as follows: The craniovertebral angle is identified as the intersection of a horizontal line passing through the C7 spinous process and a line joining the midpoint of the tragus of the ear to the skin overlying the C7 spinous process [7, 8]. A digital imaging technique was used to evaluate head and neck posture in the standing position. A digital camera was placed at a distance of 1.5 meters on a fixed base without rotation or tilt. The height of the camera was adjusted to the level of the investigated subject's shoulder and a self-balanced position was chosen to standardize the head and neck posture of subjects. The necessity of remaining in natural posture during taking photographs was explained by the assessor. The landmarks were joined on the participant's left side using double-sided tape; the spinous process of C7, and the tragus of the ear.

The examiner located the C7 spinous process by requesting the participating subject to move the cervical spine into the flexion and extension. The C7 spinous process is more prominent; however, the C6 spinous process is absent in palpation when the cervical spine is extended. A plumb rope was suspended from the ceiling, and the research subjects stood where the rope would pass to anterior the external malleolus. The plumb line defined the true vertical line on digital images. According to Kendall's definition, in a healthy posture, the external ear meatus must be in vertical alignment with the lateral malleolus (used to identify individuals without FHP). Images were obtained three times and the average was assumed for each study participant. Next, the photos were transferred to the AutoCAD software to find the craniovertebral angle. The craniovertebral angle was identified at the intersection of a horizontal line passing through the C7spinous process and a line joining the midpoint of the tragus of the ear to the skin overlying the C7 spinous process [9]. There was a clear cut-off point threshold, identifying FHP for the craniovertebral angle. Besides, the study subjects with a craniovertebral angle of <48º were recognized with FHP. The smaller the angle, the greater the intensity of the forward position.

Postural stability was measured using the BBS (Biodex, Shirley, NY). BBS is an instrument designed to measure and train the postural stability on a static or unstable surface [10]. BBS consisted of a circular platform, i.e. free to move in the anterior-posterior and medial-lateral axes, simultaneously. The BSS device is interfaced with dedicated software (Biodex, Version 1.08, Biodex, Inc.) allowing the BSS to measure the degree of tilt in each axis; accordingly, it provides an average sway score. Eight springs located underneath the outer edge of the platform provide the resistance to movement (stability level of the platform). Resistance levels range from 8 (most stable) to 1 (least stable).

BBS has a display to present feedback in real-time concerning the posture and was calibrated before the measures. The study participants stood on the BBS supporting both legs during all trials. All trials were performed barefoot. Besides, foot position was recorded using coordinates on the platform's grid to ensure the same stance; therefore, providing consistency on future tests. When the test began, the platform was released for 20 seconds; subsequently, the research subjects were requested to maintain an upright position standing on both feet. The overall stability index was considered for static and dynamic stability (level 4 at platform stability). The score on this test assesses deviations from the center; thus, a lower score is more desirable than a higher one. The study subjects were tested in eyes open and eyes closed conditions.

The normal distributions of the samples were tested by the Shapiro–Wilk test. As each parameter fitted the hypothesized normal distribution of the data (P>0.05 in the Shapiro–Wilk test), the Independent-Samples t-test was used to compare mean scores at a significance level of 0.05 in SPSS.

3. Results

Descriptive statistics concerning the individual characteristics of the study subjects, including age, height, weight, Body Mass Index (BMI), and craniovertebral angle are presented in Table 1. Postural stability values are listed in Table 2.

The Independent-Samples t-test (Table 3) data suggested no significant difference between the NFHP and FHP groups in static postural stability in eyes-open and eyes-closed status (P>0.05). In contrast, there was a significant difference between the NFHP and FHP groups in dynamic postural stability in eyes-open and eyes-closed conditions (P<0.05).

Table 1. The demographic characteristics of the research subjects

Demographic Characteristics	Mean±SD				
	Age (y)	Height (cm)	Weight (kg)	BMI (kg/m²)	Craniovertebral Angle (deg)
Non-FHP	24±4	173±6	70±6	24.68±1.1	55±3
FHP	25±3	178±7	68±5	22.54±1.4	39±7

PHYSICAL TREATMENTS

Table 2. Postural stability values

Variable	Group	No.	Mean±SD	Std. Error Difference
OSI -dynamic-open eyes	Non-FHP	15	3± 0.92	0.23
	FHP	15	4.8± 1.3	0.35
OSI -dynamic-closed eyes	Non-FHP	15	12± 2.4	0.62
	FHP	15	16.4± 1	0.26
OSI -static-open eyes	Non-FHP	15	0.36± 0.11	0.02
	FHP	15	0.38± 0.12	0.03
OSI - static -open eyes	Non-FHP	15	1.5± 0.56	0.14
	FHP	15	1.6± 0.35	0.09

PHYSICAL TREATMENTS

OSI: Overall Stability Index; Non-FHP: Non-Forward Head Posture; FHP: Forward Head Posture

Table 3. The Independent Samples t-test results for dynamic and static postural stability

Variable	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
OSI -dynamic-open eyes	3.06	0.091	-4.12	28	0.000	-1.76	0.42	-2.63	-0.88
OSI -dynamic-open eyes	10.14	0.004	-6.59	28	0.000	-4.44	0.67	-5.82	-3.06
OSI -static-open eyes	0.01	0.91	-0.46	28	0.646	-0.02	0.04	-0.1	0.06
OSI -static-closed eyes	1.76	0.19	-0.57	28	0.569	-0.10	0.17	-0.45	0.25

OSI: Overall Stability Index PHYSICAL TREATMENTS

The FHP group revealed more postural sways, indicating weaker dynamic stability, compared to the NFHP group.

4. Discussion

The current study results suggested no significant difference between the NFHP and FHP groups in static postural stability in eyes-open and eyes-closed status. However, the study groups presented a significant difference in dynamic stability in eyes-open and eyes-closed conditions; thus, the FHP group demonstrated weaker dynamic stability, compared to the NFHP group.

The present study findings are in line with those of Lynn et al. (1997), Sinaki et al. (2005), Bot et al. (1999), Yalfani et al. (2014), and Kasukawa et al. (2010) [11-16]; however, they are inconsistent with those of Imagama et al. (2011), Silva et al. (2013), and Hyong et al. (2012) [4, 17, 18].

Data collected by BBS revealed no significant differences between the NFHP and FHP groups in static postural stability. Silva et al. noted that the ability of young individuals to adapt to FHP could be a possible factor to encounter any potential negative impact on static postural stability [17]. This suggestion may indicate that individuals with FHP may have no difficulty in static postural stability, compared to the healthy ones. Furthermore, as the static testing on the BBS platform is not so much challenging, it might not have been able to present any difference in performance. Another explanation is the small sample size; investigating more subjects may reveal a different result.

In contrast to the static postural stability data, the overall index for dynamic postural stability suggested that the FHP group had more postural sways than the NFHP group. Such data indicate poorer postural stability in the FHP group. A possible explanation for poor postural stability with FHP may be the displacement of the body's COG [11]. Leaning forward the head and neck area from the line of gravity exerts an unequal pressure on the musculoskeletal structure of the neck under pressure and tension. This incorrect mechanical pressure on the neck area disables muscles to properly perform their functions. As a result, and based on the principle of the kinetic chain, if any segment of the musculoskeletal system is unable to perform its tasks well, the pressure and load of its work will be transferred to adjacent joints and muscles; eventually, the whole body is engaged to compensate.

The Greater postural sways in the FHP group could reflect the mechanical expression of greater muscle activity resulting from motor unit recruitment. Indeed, increased muscle force implies the recruitment of supplementary motor units with the capacity to contract faster. This process also helps to produce a greater acceleration in response. Attempting to maintain the head and neck area, as well as stabilizing its overall position causes the body to expend more force and oscillation to compensate for the weakness in that area. This faulty loading pattern would cause the cervical area incapable of activating the muscle synergies. Therefore, the responsibility for the inadequacy of the neck area to function properly inevitably falls on other parts of the body with greater effects. The muscles that need to compensate for the weakness of the neck area are farther away from the neck muscles, compared to the neck joints; accordingly, their contraction is with more force and torque which could be less precise and on time. This higher torque could increase the body's oscillations.

Gauchard et al. (2001) assessed the effects of idiopathic scoliosis on undisturbed postural control in young female teenagers. Their results indicated differences in the postural control between the investigated populations; the scoliotic COG motions were ampler in the test group, compared to the healthy subjects [19]. The damage to the vestibular system could be explained by a spinal deformity, especially in kyphosis and scoliosis, and the initial position of the head on the spine changes; subsequently, this change affects the vestibular system to provide incorrect information to the balance control system.

Individuals with scoliosis change the position of their joints and muscles relative to their original position; it is unlikely that this system sends the right data about the position of muscles and joints to the Central Nervous System (CNS). This may also be the case for individuals with FHP [6]. The position of the cervical vertebrae and the agonist and antagonist muscles seem to alter as the neck arch intensifies. Moreover, the articular and muscular receptors fail to transmit the correct information. With spinal deviations and deformities, the muscles on one side become short and the other side becomes weak. Accordingly, it leads to a lack of coordination between these muscles.

The cervical area also significantly impacts controlling posture and stability against gravity [20, 21]. The cervical region has a specialized proprioception system, i.e. probably due to the abundance of muscle spindles and mechanoreceptors in this area; it is especially located in the posterior cervical region [20, 21]. These cervical receptors are associated with the visual and vestibular systems [20, 21]. They also influence cervico-collic and cervico-ocular reflexes and cervical tonic reflexes, i.e.critical in regulating head, eye, and postural stability [20, 21]. During neck movement, visual, vestibular, and proprioception are constantly changing as a result of continuous alternations in the length of muscles, the visual field, and the interaction of the multi surfaces of the vertebrae [22]. FHP is accompanied by pain, fatigue, and erosion of joints, spasms, muscle tension, muscle imbalance, and decreased proprioception [1]. These, in turn, could contribute to the disturbance of postural stability [22, 23].

The postural deviations of the head and neck area could impair the data transmitted from the mechanoreceptors to the CNS [6]. This will result in an improper response of the body and the creation of inappropriate motor responses to internal and external stimuli.

Furthermore, changes in the curvature of the spine could lead to an insufficient tension-length relationship, increased fatigue, and enhanced electromyography activity of the muscles in different areas of the spine. Due to changes in the curvature of the spine caused by head abnormalities and body mass in a new position, the body's mass changes are relative to the ankle joint; subsequently, this condition changes the ankle's torque and increases the activity of the lower limb muscles. In sum, all of these changes could affect the input of receptors to regulate COP, which in turn, affects the postural control [5].

As per the present study, the mechanisms involved in dynamic postural stability were affected by FHP. In the BBS, when the dynamic mode is selected for measurement, the footrest is less stabilized. The addition of footrest instability could generate a significant difference between the FHP and NFHP groups in dynamic stability. However, the performance of the study groups revealed no significant difference in the static mode. Our research finding suggested that different mechanisms might be involved in controlling static and dynamic postural stability; static postural control is different from dynamic control. Such data reveal that static postural stability does not necessarily reflect or guarantee dynamic postural stability. In this regard, few studies directly examined the relationship between static and dynamic stability; the results of which indicated poor relationships between static and dynamic stability [23, 24].

FHP could demonstrate its negative effects on dynamic stability. The body encountered further turbulences with greater forces and torques while the test was dynamic. Individuals with FHP could compensate and normally function in the static stability test; however, with more disturbances, they failed to keep the same performance as the normal ones. In this study, the tests of postural stability were conducted in the laboratory and by the BBS. Besides, the results might not be generalizable to real situations,; therefore, conducting research with field and functional tests may help produce useful knowledge about the impact of FHP on postural stability.

5. Conclusion

FHP, as a postural deviation, not only removes the head and neck area from the anatomical point of view but also could weaken the individual's performance in controlling dynamic postural stability.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed about the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

All authors contributed equally in preparing all parts of the research.

Conflict of interest

The authors declared no conflicts of interest.

Acknowledgments

The authors sincerely appreciate the study participants and the Sport Sciences Research Institute of Iran who helped us in conducting this research.

References:

[1] Koseki T, Kakizaki F, Hayashi S, Nishida N, Itoh M. Effect of forward head posture on thoracic shape and respiratory function. Journal of Physical Therapy Science. 2019; 31(1):63-8. [DOI:10.1589/jpts.31.63] [PMID] [PMCID]

[2] Shumway-Cook A, Woollacott MH. Motor control: Theory and practical applications. Philadelphia: Lippincott

Williams & Wilkins; 2001. https://books.google.com/books?id=301hQgAACAAJ&dq

[3] 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]

[4] Hyong IH, Kim JH. The effect of forward head on ankle joint range of motion and static balance. Journal of Physical Therapy Science. 2012; 24(9):925-7. [DOI:10.1589/jpts.24.925]

[5] Kang JH, Park RY, Lee SJ, Kim JY, Yoon SR, Jung KI. The effect of the forward head posture on postural balance in long time computer based worker. Annals of Rehabilitation Medicine. 2012; 36(1):98-104. [DOI:10.5535/arm.2012.36.1.98] [PMID] [PMCID]

[6] Lee MY, Lee HY, Yong MS. Characteristics of cervical position sense in subjects with forward head posture. Journal of Physical Therapy Science. 2014; 26(11):1741-3. [DOI:10.1589/jpts.26.1741] [PMID] [PMCID]

[7] Salahzadeh Z, Maroufi N, Ahmadi A, Behtash H, Razmjoo A, Gohari M, et al. Assessment of forward head posture in females: Observational and photogrammetry methods. Journal of Back and Musculoskeletal Rehabilitation. 2014; 27(2):131-9. [DOI:10.3233/BMR-130426] [PMID]

[8] Nemmers TM, Miller JW, Hartman MD. Variability of the forward head posture in healthy community-dwelling older women. Journal of Geriatric Physical Therapy. 2009; 32(1):10-4. [DOI:10.1519/00139143-200932010-00003] [PMID]

[9] Fernandez-de-Las-Penas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Forward head posture and neck mobility in chronic tension-type headache: A blinded, controlled study. Cephalalgia. 2006; 26(3):314-9. [DOI: 10.1111/j.1468-2982.2005.01042.x]

[10] Parraca JA, Olivares PR, Baeza C, Aparicio VA, Adsuar JC, Gusi N. Test-Retest reliability of Biodex Balance SD on physically active old people. ournal of Human Sport and Exercise. 2011; 6(2):444-51. [DOI:10.4100/jhse.2011.62.25]

[11] Bot SD, Caspers M, Van Royen BJ, Toussaint HM, Kingma I. Biomechanical analysis of posture in patients with spinal kyphosis due to ankylosing spondylitis: A pilot study. Rheumatology (Oxford). 1999; 38(5):441-3. [DOI:10.1093/rheumatology/38.5.441] [PMID]

[12] Hamedani P, Seydi F. The effect of central muscle functional fatigue on postural fluctuation in female athletes. Sport Medicine (Harakat). 2015; 6(2):131-51. https://www.sid.ir/en/journal/ViewPaper.aspx?id=415792

[13] Lynn SG, Sinaki M, Westerlind KC. Balance characteristics of persons with osteoporosis. Archives of Physical Medicine and Rehabilitation. 1997; 78(3):273-7. [DOI:10.1016/S0003-9993(97)90033-2]

[14] Kasukawa Y, Miyakoshi N, Hongo M, Ishikawa Y, Noguchi H, Kamo K, et al. Relationships between falls, spinal curvature, spinal mobility and back extensor strength in elderly people. Journal of Bone and Mineral Metabolism. 2010; 28(1):82-7. [DOI:10.1007/s00774-009-0107-1] [PMID]

[15] Anbarian M, Mokhtari M, Zareie P, Yalfani A. [A comparison of postural control characteristics between subjects with kyphosis and controls (Persian)]. Avicenna Journal of Clinical Medicine. 2010; 16(4):53-60. http://sjh.umsha.ac.ir/article-1-300-en.html

[16] Sinaki M, Brey RH, Hughes CA, Larson DR, Kaufman KR. Balance disorder and increased risk of falls in osteoporosis and kyphosis: Significance of kyphotic posture and muscle strength. Osteoporosis International. 2005; 16(8):1004-10. [DOI:10.1007/s00198-004-1791-2] [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] Imagama S, Matsuyama Y, Hasegawa Y, Sakai Y, Ito Z, Ishiguro N, et al. Back muscle strength and spinal mobility are predictors of quality of life in middle-aged and elderly males. European Spine Journal. 2011; 20(6):954-61. [DOI:10.1007/s00586-010-1606-4] [PMID] [PMCID]

[19] Gauchard GC, Lascombes P, Kuhnast M, Perrin PP. Influence of different types of progressive idiopathic scoliosis on static and dynamic postural control. Spine. 2001; 26(9):1052-8. [DOI:10.1097/00007632-200105010-00014] [PMID]

[20] Swait G, Rushton AB, Miall RC, Newell D. Evaluation of cervical proprioceptive function: Optimizing protocols and comparison between tests in normal subjects. Spine. 2007; 32(24):E692-701. [DOI:10.1097/BRS.0b013e31815a5a1b] [PMID]

[21] Schieppati M, Nardone A, Schmid M. Neck muscle fatigue affects postural control in man. Neuroscience. 2003; 121(2):277-85. [DOI:10.1016/S0306-4522(03)00439-1]

[22] Humphreys BK, Irgens PM. The effect of a rehabilitation exercise program on head repositioning accuracy and reported levels of pain in chronic neck pain subjects. Journal of Whiplash & Related Disorders. 2002; 1(1):99-112. [DOI:10.3109/J180v01n01_09]

[23] Hrysomallis C, McLaughlin P, Goodman C. Relationship between static and dynamic balance tests among elite Australian footballers. Journal of Science and Medicine in Sport. 2006; 9(4):288-91. [DOI:10.1016/j.jsams.2006.05.021] [PMID]

[24] Karimi MT, & Solomonidis S. The relationship between parameters of static and dynamic stability tests. Journal of Research in Medical Sciences. 2011; 16(4):530-5. [PMID] [PMCID]

This Page Intentionally Left Blank