Effect of Forward Head Posture on Dynamic Balance Based on the Biodex Balance System

Alireza Ahmadipoor[1][ⓘ], Khosro Khademi-Kalantari[2]*[ⓘ], Asghar Rezasoltani[2], Sedigheh-Sadat Naimi[2], Alireza Akbarzadeh-Baghban[2]

[1]MSc, Physiotherapy Research Center, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]PhD, Physiotherapy Research Center, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

ABSTRACT

Forward Head Posture (FHP) results in spine malalignment, muscle imbalance and cervical proprioception sensory input impairment. Subjective description of FHP is interpreted differently by clinicians and therefore the FHP is classified as slight, moderate and sever. This study aimed to evaluate balance disorder in individuals with severe forward head posture (FHP). Twenty individuals with severe FHP and 20 controls were enrolled. Dynamic postural stability was assessed in all participants using the Biodex Balance System (BBS) in semi dynamic position with eye open/eye closed conditions. Based on the findings, dynamic postural stability in the sagittal plane was different between the groups ($P<0.05$). It can be concluded that impairment of dynamic postural stability occurs in individuals with severe FHP. The findings suggest that clinicians take into account the importance of dynamic postural stability assessment in FHP subjects and consider the application of intervention programs for improvement of the dynamic balance.

Introduction

Forward head posture (FHP) refers to a complication in which the head is anterior to a vertical line passing through the center of gravity (COG). It is recognized as a frequent deviation in posture, involving musculoskeletal balance disorders [1].

Balance enables the body to maintain its center of mass within the base of support (BOS) with the least postural sway. It is considered an essential element in daily activities, integrating sensory (i.e., vestibular, visual, and somatosensory inputs) and musculoskeletal systems [2]. Postural changes can influence COG within BOS and consequently lead to balance disorder. In FHP, a cause of balance disorder may be proprioceptive impairment. A variety of laboratory examinations, such as force platform, are used to assess postural stability in individuals with FHP [3]. Despite the common application of force platforms in the assessment of parameters related to the center of pressure, they

*Corresponding author:
Khosro Khademi-Kalantari
Physiotherapy Research Center, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
E-mail: khosro_khademi@yahoo.co.uk

cannot effectively describe the standing posture control in mediolateral and anteroposterior axes [4].

On the other hand, cost-effective force platforms, such as Biodex Balance System (BBS), which can evaluate static and quasi-dynamic balance in anteroposterior and mediolateral directions, are useful in the assessment of dynamic balance and postural stability [5]. According to a study by Pickerill et al. since the BOS size changes constantly on an unstable Biodex Stability System (BSS) platform, this tool can be applied in the evaluation of functional stability [6].

In previous research on FHP and balance, changes in postural balance and balance disorder have been reported [7]. Nevertheless, the effects of FHP on balance have not been investigated using BBS.

The present study aimed at comparing dynamic standing balance in people with and without FHP based on BBS.

Material and Methods

Design

Forty participants (20 with FHP and 20 without FHP) were enrolled in this study. The participants had no history of fracture, neuromuscular disorders, or moderate to severe scoliosis. According to the craniovertebral angle (CVA), the subjects were divided into FHP (CVA<53°) and control (CVA≥53°) groups. FHP is commonly assessed on lateral images, as adopted in the present study. The camera was positioned as high as the participant's shoulder. After marking the tragus, we taped a plastic pointer to the skin covering the C7 spinous process and measured CVA. CVA was described as the angle between a line extending from the ear tragus to C7 and a horizontal line passing through C7.

Instrumentation

The neuromuscular performance was examined using BSS (Biodex, USA) by as-

sessing the individual's ability to remain stable on an unstable platform [4, 5]. There is a movable balance platform in the BSS system, which allows a surface tilt of 20°. Horizontal deviations are indicated by the unstable platform movements. In addition, the anterior-posterior stability index (APSI), overall stability index (OSI), and medial-lateral stability index (MLSI) were calculated.

There are generally eight levels of stability in the BSS system, ranging from a completely firm to a very unstable surface [3, 8]. OSI represents displacement of the foot platform during motion analysis, while the stability index is determined as the angular COG excursion. Moreover, AP indicates the variance in platform displacement in the sagittal plane, and ML represents the frontal plane motion. On the other hand, the person's overall ability to maintain a steady position is represented by OSI [4].

Protocol

In this study, the test included three trials while standing on a dynamic platform (bilateral and unilateral stance) for 20 seconds per trial with eyes both open and closed. Next, the mean score of three trials was calculated. The examinee participated in the balance test in a random order. We changed the level of stability from level 8 to 4 and from level 6 to 3 for unilateral and bilateral evaluations, respectively. The participants were asked to keep the center of pressure in the smallest concentric circles (zone A). In all evaluated subjects, the right leg was dominant, which was used accordingly for stability in unilateral stance. In addition, we evaluated dynamic postural stability according to APSI, MLSI, and OSI in four states (i.e., double-leg stance with eyes open and closed and single-leg stance with eyes open and closed). There was a 60-second rest period between trials. Generally, in postural stability measurements, a higher score indicates excessive motion, while a lower score represents better

postural stability.

All participants signed a consent form in this study. Also, the ethics committee approved the study protocol.

Data Analysis

Shapiro-Wilk test was performed to determine the normal distribution of data. Quantitative data were compared between the groups using student's *t-test*. SPSS version 23 (USA) was used for all analyses, and $P<0.05$ was considered significant.

Results

Age, BMI and craniovertebral angle (CVA) in the FHP group was 36.65±4.11, 23.46±3.12, 46.18±1.55 and control group was 37.15±4.8, 23.8±3.77, 53.34±1.88 respectivly.

The dynamic postural stability indices of both groups are shown in Table 1. There were significant inter-group differences regarding OSI and APSI ($P<0.05$) (Table 1).

Discussion

Balance disorder is a common challenge in individuals with FHP. The current study aimed to evaluate dynamic balance using BBS. Dynamic postural stability indices were significantly impaired in individuals with FHP, compared to the controls. According to the results, OSI, APSI, and MLSI were significantly different between individuals with and without FHP.

FHP shifts the body's COG, inducing dynamic changes in posture and affecting the torso and joints. Balance also changes as a physical response to FHP. On the other hand, imbalanced weight support by the lower limbs diminishes the balance ability [8]. In our study, the participants had severe FHP. FHP may be associated with increased postural sway in single- or double-leg stance with eyes closed in OSI and APSI. In this regard, Lee et al. [7] examined individuals with FHP proprioceptive deficits and compared them with healthy subjects. This result implies that the change in the muscle length caused by FHP decreases the joint position sense.

Integration of sensory information from vestibular, visual, and somatosensory inputs is essential to improve proper postural control and balance by providing more accurate postural cues. In fact, postural stability training with closed eyes should be integrated in the FHP physiotherapy program, given its positive effect on proprioception. Moreover, the present results showed a significant difference in terms of balance control on APSI between individuals with closed and open eyes; therefore, vision is a major factor in balance control.

Balance disorder in individuals with FHP can be explained by the center of mass displacement in the sagittal plane. In this condition, the center of pressure moves forward, possibly due to the significant postural sway in the sagittal plane; this in turn increases the unbalanced feeling related to the back muscle load and triggers the body to overreact for preventing backward falling. In line with the present study, Johnson et al. in a study on the impact of head position on postural control, revealed the importance of head extension. This finding was confirmed by the increased center-of-foot pressure velocity in the anterior/posterior axes, as well as the shorter time to contact the anterior/posterior stability boundary [9].

In the present study, there was a significant difference in MLSI, which might be related to the fact that movement of a distal segment requires control of the proximal segment [10]. Additionally, it can be assumed that individuals with FHP use different strategies to maintain balance [11]. In the current study, lower OSI and AP stability of the control group, compared to the FHP group, might be associated with better balance control in the

Table 1: Postural Stability Indices of Individuals with and without forward head posture (FHP)

Variables	Control Group (N=20)	FHP Group (N=20)	P-Value
Double-leg, eyes open			
OSI	1.76 (0.99)	3.64 (1.69)	S
APSI	1.5 (0.56)	2.56 (1.23)	S
MLSI	1.22 (1.14)	2.75 (1.31)	S
Double-leg, eyes closed			
OSI	6.65 (2.64)	10 (1.74)	S
APSI	5 (1.87)	7.09 (1.45)	S
MLSI	5.86 (1.27)	7.19 (1.68)	S
Single-leg, eyes open			
OSI	1.41 (0.47)	2.37 (0.75)	S
APSI	1.88 (0.77)	1.14 (0.81)	S
MLSI	1.02 (0.23)	1.64 (0.43)	S
Single-leg, eyes closed			
OSI	5.79 (2.21)	7.69 (2.3)	S
APSI	3.47 (2.19)	4.85 (2.41)	S
MLSI	5.22 (2.05)	6.44 (2.24)	S

FHP: Forward head posture, NS: Non-significant, OSI: Overall stability index, APSI: Anterior-posterior stability index, MLSI: Mediallateral stability index, S: Significant

control group.

In the literature, although different methods have been used to investigate dynamic balance in FHP, most studies have reported impairment in static postural stability; this result may be attributed to the structural changes of the musculoskeletal system. Moreover, other factors, such as quality of life and psychological status, can disturb postural sway indices in single- or double-leg stance with eyes open or closed.

The results of few studies are inconsistent with the present findings. In a study by Um et al. FHP did not affect static balance significantly. Nevertheless, the sample in their study included children, who generally have a lower COG than adults; therefore, the effect of postural deformity on balance control might be limited. Also, they examined the effect of FHP on static balance, not dynamic balance [12].

The present study had some limitations.

Since the study sample only included healthy adult men, generalization of the findings may be difficult. Therefore, the effect of FHP on gait kinetics and kinematics needs to be examined in future studies.

Conclusion

This study showed that static and dynamic postural stability significantly changed due to FHP. However, the positive effects of balance training need to be confirmed in future studies on individuals with FHP.

Acknowledgment

The authors would like to acknowledge the generous assistance of all participants and staff of school of physiotherapy, Shahid Beheshti University of Medical Sciences.

Authors' Contribution

A. Ahmadipoor, Kh. Khademi-Kalantari, A. Rezasoltani and SS. Naimi were responsible for the study design. A. Ahmadipoor and Kh. Khademi-Kalantari collected and prepared the data. A. Ahmadipoor, A. Rezasoltani and AR. Akbarzadeh-Baghban analyzed the data. A. Ahmadipoor and Kh. Khademi-Kalantari were responsible for writing and redrafting the manuscript. All authors read and approved the final manuscript.

Ethical Approval

The study protocol was approved by Human Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.REC.1398.106).

Informed consent

Written consent was obtained from the participants and informed about the aims and objectives before enrolling in the study.

Conflict of Interest

None

References

1. 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. PubMed PMID: 23219786.

2. 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. PubMed PMID: 26957773. PubMed PMCID: PMC4756019.

3. Parraca JA, Olivares Sánchez-Toledo PR, Carbonell Baeza A, Aparicio García-Molina VA, et al. Test-Retest reliability of Biodex Balance SD on physically active old people. *Journal of Human Sport and Exercise.* 2011;**6**(2):444-51. doi: 10.4100/jhse.2011.62.25.

4. Winter DA, Patla AE, Frank JS. Assessment of balance control in humans. *Med prog Technol.* 1990;**16**(1-2):31-51. PubMed PMID: 2138696.

5. Cug M, Wikstrom EA. Learning effects associated with the least stable level of the Biodex® stability system during dual and single limb stance. *J Sports Sci Med.* 2014;**13**(2):387-92. PubMed PMID: 24790494. PubMed PMCID: PMC3990894.

6. Pickerill ML, Harter RA. Validity and reliability of limits-of-stability testing: a comparison of 2 postural stability evaluation devices. *J Athl Train.* 2011;**46**(6):600-6. doi: 10.4085/1062-6050-46.6.600. PubMed PMID: 22488184. PubMed PMCID: PMC3418936.

7. Lee MY, Lee HY, Yong MS. Characteristics of cervical position sense in subjects with forward head posture. *J Phys Ther Sci.* 2014;**26**(11):1741-3. doi: 10.1589/jpts.26.1741. PubMed PMID: 25435690. PubMed PMCID: PMC4242945.

8. Lee CM, Jeong EH, Freivalds A. Biomechanical effects of wearing high-heeled shoes. *International Journal of Industrial Ergonomics.* 2001;**28**(6):321-6. doi: 10.1016/S0169-8141(01)00038-5.

9. Johnson MB, Van Emmerik RE. Effect of head orientation on postural control during upright stance and forward lean. *Motor Control.*

2012;**16**(1):81-93. doi: 10.1123/mcj.16.1.81. PMID: 22402222.

10. McMullen J, Uhl TL. A kinetic chain approach for shoulder rehabilitation. *J Athl Train.* 2000;**35**(3):329. PubMed PMID: 16558646. PubMed PMCID: PMC1323395.

11. Putnam CA. A segment interaction analysis of proximal-to-distal sequential segment motion patterns. *Medicine and Science in Sports and Exercise.* 1991;**23**(1):130-44. PubMed PMID: 1997807.

12. Um JY. Correlation between forward head posture and body weight support distribution & static balance ability of children in growth phase [dissertation]. South Korea: Kyoung Hee University; 2014.