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Relationship between Posture Changes and Each of Ankle Joint Range of Motion and Dynamic Balance

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Abstract

Background: Various activities of daily living require sitting for prolonged periods of time. These activities include driving a car, working on a computer. This can lead to postural changes such as exaggerated forward head posture. Which can lead to over activation of the ankle plantar flexor to maintain body balance. On the other hand, ankle movement may be restricted as the body is connected through fasciae network were the upper quadrant disturbance may affect lower quadrant.

Aim of Study: The current study aimed to determine the relationship between forward head posture and both ankle joint range of motion and dynamic balance in 35 healthy students. Their age ranged from 19 to 22 years.

Material and Methods: Posture was evaluated using Biotonix posture print while Biodex stability system was used to evaluate dynamic postural control. Universal goniometer was used to measure ankle joint range of motion.

Results: Three-Dimensional (3-D) head posture changes affected dynamic balance at level four of the Biodex dynamic balance test (only medio-lateral stability index), while no changes were observed in the dynamic balance at level eight. Three-dimensional head posture changes affected ankle joint range of motion.

Conclusion: Three-dimensional head posture changes affected ankle joint range of motion through the fascial system which connects different body segments with each other. Dynamic balance was also affected as changes of head posture alters center of gravity position.

Key Words: *Forward head posture – Balance – Ankle ROM – Posture.*

Introduction

PROPER posture is achieved by maintaining musculoskeletal balance associated with minimal stress or strain on the body [1]. Vision, vestibular, somatosensory, musculoskeletal and proprioceptive systems are important factors for balance [2-4]. Poor posture results in malalignment of various body parts causing greater risk of musculoskeletal injury due to increased strain on supporting structures [1,5].

Mechanoreceptors (e.g., muscle spindles) in the cervical region, have a main role in providing proprioceptive information [14]. Cervical joint position sense has a major effect on body balance, postural awareness and gait control [15]. Forward Head Posture (FHP) is a common postural disorder caused by extension in the upper cervical vertebra and flexion in lower cervical vertebra, which leads to excessive facet joints loading and weakness of the deep neck flexors and shortening of cervical extensors [6-10]. FHP causes decreased Range of Motion (ROM) in the neck, in the sagittal plane [11], and thus might influence joint position sense via muscle spindles [12]. This can also imply that proprioception becomes worse as FHP becomes more severe [13].

Studies showed that frequent computer users have decreased ability to control posture and maintain balance even if no symptoms of pain or any other musculoskeletal disorders are present [16]. This may be explained by anterior head translation position that leads to anterior displacement of Center of Gravity (COG) causing disturbance in both static and dynamic balance resulting in higher incidence for falling and musculoskeletal injuries [17,18]. Another explanation, is FHP is associated with contraction in the cervical extensors and is transmitted through the myofascial system to the plantar flexors of the ankle that are over activated to counter anterior COG translation, to maintain balance [19].

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Hence, over activation of ankle planter flexors results in disruption of ankle ROM and dynamic balance. This may result in frequent falling and musculoskeletal disorders. The purpose of the current study is to show if there is a relationship between FHP, ankle ROM and dynamic balance.

Material and Methods

At Cairo University Faculty of Physical Therapy Biodex Lab and at Misr University posure print lab, in the period from December 2015 to January 2017 (thirty-five collegiates with asymptomatic FHP participated in this study. Their age ranged from 19-22 years. Body mass index ranged from 18.5-24.9. Valid and reliable weight and height scales were used to select subjects. Subjects were excluded if they had any of the following: Visual, auditory or perceptual deficits, structural deformities at any joint of the Lower Limbs (LL) and spine, surgical operations in the lower limb, deep sensory loss, history of epilepsy, previous cervical trauma and history of ankle sprain.

Posture was evaluated using the Biotonix posture print which is computer analysis software of posture in terms of rotations in degrees and translation in millimeters [20] posture print computer code calculates static postures of the head, rib cage, and pelvis as in rotations (Rx, Ry, Rz) in degrees [20] and translations as displacements from a normal upright stance (Tx, Tz) in millimeters (mm) [20,21]. The current study measured head, rib cage, and pelvic postures as rotations and translations in three-dimensions (3-D) during standing (upright stance) using computerized system, posture Print®. In two separate validity studies, the posture Print ® system was found to be accurate in measuring head and thoracic cage postures in five degrees of freedom which are lateral translation (Tx), lateral flexion (Rz), axial rotation (Ry), flexion-extension (Rx), and anterior-posterior translation (Tz) [21,23].

Biodex balance system was used to asses dynamic balance for selected subjects.

All subjects were tested on the stability level four and level eight for three times repetitions. Test duration 20 second for each repetition.

At the end of each test trial, a printout report was obtained including information regarding Overall Stability Index (OASI), Mediolateral Stability Index (MLSI) and Anteroposterior Stability Index (APSI). High value represented that the subject had difficulties maintaining balance. Mean values of three trials were calculated for each subject.

Statistical analysis:

- Descriptive statistics was conducted to calculate the mean, standard deviation (± SD) for all measured variables.
- Pearson product moment correlation coefficient was conducted to determine the correlation between variables.
- The level of significance for all statistical tests was set at $p \leq 0.05$.
- All statistical measures were performed through the Statistical Package for Social Studies (SPSS) Version 19 for windows.

Results

Thirty-five students with forward head posture, 10 females with reported percentage of 29% and 25 males with reported percentage of 71% participated in this study. The mean ± SD of age, weight, height, and BMI were 19.62±0.73 years, 67.71 ± 10.25kg, 169.77±7.17cm, and 23.5±3.22kg/m^2 respectively. Correlation between 3D head posture changes, dynamic balance and ankle joint ROM showed moderate positive significant correlation between MLSI and head Tx (r=0.33, p=0.05). Correlations between left ankle active dorsi flexion ROM and head postural changes showed moderate positive significant correlation with head Ry (r= 0.48, p=0.003).

Correlations between left ankle active plantar flexion ROM and head postural changes showed moderate negative significant correlation with head Rx (r=–0.334, p=0.05). Correlations between right ankle active dorsi flexion ROM and postural changes indices showed moderate negative significant correlation with head postural index (r=–0.39, p= 0.01).

Correlations between right ankle active plantar flexion ROM and postural changes indices showed moderate positive significant correlation with head postural index (r=0.4, p=0.01) and a moderate positive significant correlation with total postural index (r=0.37, p=0.02).

Correlations between left ankle active planter flexion ROM and postural changes indices showed moderate positive significant correlation with head postural index (r=0.37, p=0.02) and a moderate positive significant correlation with total postural index (r=0.36, p=0.03).

Table (1): Correlation between stability indices at level 4 and head postural changes.

Stability index	Head postural changes	*r*-value	*p*-value
• Anteroposterior stability index	Head Rx (degrees)	0.01	0.92
	Head Rz (degrees)	0.1	0.55
	Head Ry (degrees)	–0.2	0.23
	Head Tz (mm)	0.14	0.4
	Head Tx (mm)	0.17	0.32
• Mediolateral stability index	Head Rx (degrees)	–0.04	0.82
	Head Rz (degrees)	0.15	0.37
	Head Ry (degrees)	–0.09	0.57
	Head Tz (mm)	0.1	0.55
	Head Tx (mm)	0.33	0.05*
• Overall stability index	Head Rx (degrees)	0.03	0.82
	Head Rz (degrees)	0.12	0.46
	Head Ry (degrees)	–0.14	0.41
	Head Tz (mm)	0.12	0.49
	Head Tx (mm)	0.21	0.22

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

Table (2): Correlation between stability indices at level 8 and head postural changes.

Stability index	Head postural changes	*r*-value	*p*-value
• Anteroposterior stability index	Head Rx (degrees)	–0.13	0.44
	Head Rz (degrees)	0.17	0.31
	Head Ry (degrees)	0.03	0.85
	Head Tz (mm)	0.17	0.32
	Head Tx (mm)	0.04	0.78
• Mediolateral stability index	Head Rx (degrees)	–0.18	0.28
	Head Rz (degrees)	0.04	0.78
	Head Ry (degrees)	–0.18	0.29
	Head Tz (mm)	0.14	0.41
	Head Tx (mm)	0.12	0.46
• Overall stability index	Head Rx (degrees)	–0.21	0.2
	Head Rz (degrees)	0.21	0.22
	Head Ry (degrees)	0.002	0.99
	Head Tz (mm)	0.19	0.25
	Head Tx (mm)	0.1	0.55

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

Table (3): Correlation between stability indices at level 4 and postural changes indices.

Stability index	Postural changes indices	*r*-value	*p*-value
• Anteroposterior stability index	Head postural index	–0.06	0.7
	Total postural index	–0.23	0.17
• Mediolateral stability index	Head postural index	–0.08	0.62
	Total postural index	–0.14	0.41
• Overall stability index	Head postural index	–0.05	0.77
	Total postural index	–0.15	0.36

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

Table (4): Correlation between stability indices at level 8 and postural changes indices.

Stability index	Postural changes indices	*r*-value	*p*-value
• Anteroposterior stability index	Head postural index	0.11	0.49
	Total postural index	–0.17	0.31
• Mediolateral stability index	Head postural index	0.1	0.54
	Total postural index	–0.07	0.68
• Overall stability index	Head postural index	0.12	0.47
	Total postural index	–0.17	0.3

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

Table (5): Correlation between ankle active ROM and head postural changes.

Ankle active ROM (degrees)	Head postural changes	*r*-value	*p*-value
• Right ankle dorsi flexion	Head Rx (degrees)	0.29	0.08
	Head Rz (degrees)	–0.13	0.45
	Head Ry (degrees)	0.03	0.84
	Head Tz (mm)	–0.32	0.06
	Head Tx (mm)	0.12	0.47
• Right ankle plantar flexion	Head Rx (degrees)	–0.3	0.07
	Head Rz (degrees)	0.18	0.29
	Head Ry (degrees)	0.2	0.23
	Head Tz (mm)	0.17	0.31
	Head Tx (mm)	0.13	0.43
• Left ankle dorsi flexion	Head Rx (degrees)	0.05	0.77
	Head Rz (degrees)	0.14	0.41
	Head Ry (degrees)	0.48	0.003*
	Head Tz (mm)	–0.05	0.77
	Head Tx (mm)	0.03	0.83
• Left ankle plantar flexion	Head Rx (degrees)	–0.334	0.05*
	Head Rz (degrees)	0.21	0.22
	Head Ry (degrees)	0.33	0.053
	Head Tz (mm)	0.15	0.36
	Head Tx (mm)	0.05	0.77

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

Table (6): Correlation between ankle active ROM and postural changes indices.

Ankle active ROM (degrees)	Postural changes indices	*r*-value	*p*-value
• Right ankle dorsi flexion	Head postural index	–0.39	0.01*
	Total postural index	–0.24	0.16
• Right ankle plantar flexion	Head postural index	0.4	0.01*
	Total postural index	0.37	0.02*
• Left ankle dorsi flexion	Head postural index	0.23	0.18
	Total postural index	0.327	0.055
• Left ankle plantar flexion	Head postural index	0.37	0.02*
	Total postural index	0.36	0.03*

r-value: Correlation coefficient value.
p-value: Probability value.
p=0.05 significant.

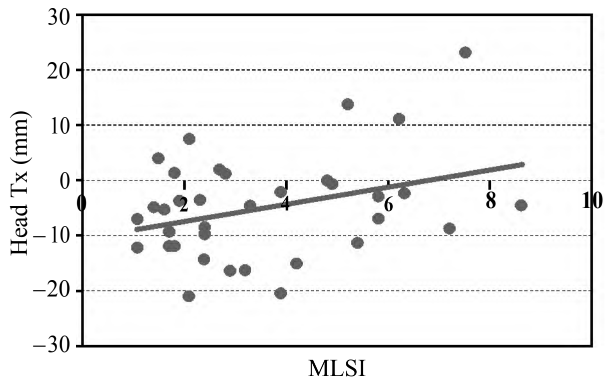

Fig. (1): Correlation between head Tx and MLSI.

Discussion

Nowadays, use of Visual Display Terminals (VDT) of computers and smart phones is very common [24]. Which results in musculoskeletal disorders such as FHP, which is one of the most common conditions [25]. A study by Kang et al., showed that heavy computer users had significantly decreased ability to control posture and mobility compared to the control group, even though they do not necessarily complain of severe pain caused by musculoskeletal disorders such as myofascial pain syndrome or herniated disc [26].

Disorders in the cervical region and its connection with balance can be further explained by fascial net which is a continuous net, were when agonist muscles contract the whole myofascial net is affected and pulled into a specific direction, and because of the net's consistency the rest of the muscles are somehow affected [27].

Muscle tension is transmitted by tendons, the endomysium, perimysium and epimysium and by extramuscular connective tissues, such as the deep fasciae and the neurovascular tract [28]. Fasciae play an important role in the transmission of force, thus regulating human posture and balance [29]. and in proprioception, as encapsulated receptors (e.g., the Ruffini and Pacini corpuscles) are located within [30].

According to Myers, the superficial back line is one of myofascial meridians transmitting the tension generated by the head or gastrocnemius to other muscles [31]. The current study confirmed that human muscles relate to each other by fascia enabling interaction with each other, as changes in the head posture affected ankle ROM.

Previous studies observed that increased hamstring muscle flexibility following the release of suboccipital muscles. Through the action of the superficial back line [9], that connects muscles on the posterior side of the body with each other, passive hamstring stretching exercises stretched the cervical extensors, and the stretched extensor loosened the flexors increasing cervical flexion and extension. The passive hamstring stretching exercises also transmitted the force of stretching to muscles related to the pelvis and spine, thereby improving static balance [19,33,34].

A study by Ellis, [35]. Reported minimal displacement of the sciatic nerve at the thigh during cervical spine flexion in a sitting position.

Peripheral neural tissue is connected to the surrounding fascia through the epineurium, making force transmission not only be through fascial tissue, but also through neural tissue [36].

During cervical flexion, force transmitted through the fascial pathway may also be transmitted through the posterior lamina of the thoracolumbar fascia, which is one of the main dorsal pathways of force transmission that directly connects to the gluteus maximus and hamstring fascia [37].

The neural pathway, which involves the spinal cord, spinal dura, and lumbosacral roots, creates tension in the sciatic nerve with different types of joint movements, including cervical spine flexion [38,39].

In the hamstring, the fascial tissue and sciatic nerve have a connection through the epineurium. This effect can be explained by a connection of the hamstring tendons with the suboccipital muscle through a neural system that passes through the spinal dura, part of the posterior myofascial chain [40,41].

Cruz-Montecinos et al., [42] in their study to investigate ultrasound assessment of fascial connectivity in the LL during maximal cervical flexion proved displacement of deep fascia thus suggesting myofascial connectivity between the cervical spine and the LL. This agrees with results if the current study where changes in the head posture affected ankle joint ROM.

Hyouk Hyong and Jae Hyun Kim, [43,44]. Examined the effect of forward head posture on ankle joint ROM and static balance reported that forward head posture affects normal ankle plantar flexion ROM through the fascia, which proves that human body parts have transmit tensions arising from different postures among each other through the fascia but no influence on static balance. Tension in the human body is transmitted by fascia through myofascial meridians with possible influence on the biomechanics of the distal joints **[22]**. Which agrees with results of the current study. From a biomechanical point of view, fascia plays important roles in movement restriction and proprioception.

This restriction has been observed in fascial connectivity models, such as between the pelvis and deep fascia of the medial gastrocnemius **[43]**.

And has been reinforced by observations in cadaveric models, which suggest posterior fascial connectivity between the thoracolumbar spine, pelvis, and feet **[45]**.

Sivayogam A, Johnson GM, Skinner MA **[46]** investigated the influence of change in head posture (e.g., retraction and protrusion) on postural stability. The results demonstrate that in healthy young adult males, no significant difference in the equilibrium score was detected when the head was positioned in protrusion or retraction compared with the neutral head posture in any of the six different test conditions for balance. However, the results from this study suggest that despite protrusion and retraction of the head, postural stability was able to be maintained. The likely explanation is that in protrusion and retraction the head orientation with respect to the horizontal ground surface was unaltered; hence the vestibular system was in a good state to assist with controlling postural stability and furthermore the compression effect on the vertebral artery that can be identified during head extension is not evident in head protrusion and retraction **[47]**.

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The results of this study supports our study results as changes of head posture did not affect the dynamic balance.

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العلاقة بين الوضعيات المختلفة وكل من مدى الحركة لمفصل الكاحل والإتزان الديناميكى

خلفية: يكثر إستخدام أجهزة الكمبيوتر ووسائل التواصل الإجتماعى بل وقضاء أوقات طويلة من اليوم أمام الشاشات بهدف زيادة كفاءة وإنتاجية العمل وتوفير الوقت والمجهود وأيضا قضاء أوقات طويلة على الكرسى بغرض المذاكرة أو فى المواصلات وكل هذا يؤدى إلى تغيرات فى وضعية الرأس وأكثرها شيوعا هو الوضع الأمامى للرأس، وهذا قد يؤثر على مناطق مجاورة للرقبة مثل الكتف أو بعيدة عنها مثل مفصل الكاحل عن طريق النسيج الضام حتى لو لم يعانى هؤلاء الطلاب من أى أعراض أو ألم. حيث أثبتت الأبحاث أن النسيج الضام يربط بين كل مناطق الجسم بل وبين الأنسجة المختلفة وأيضا ينقل القوة والشد فى العضلات من مكان لآخر.

الغرض: يهدف هذا البحث إلى دراسة العلاقة بين وضعية الرأس وكل من مدى الحركة لمفصل الكاحل والإتزان الديناميكى لدى الطلاب الجامعيين.

الأشخاص: وقد أجريت هذه الدراسة على عينة مكونة من خمسة وثلاثون طالبا تم قياس الإتزان الديناميكى لهم عن طريق جهاز البيودكس وأيضا تحليل ثلاثى الأبعاد لوضعية الرأس وقياس مدى الحركة لمفصل الكاحل لربط العلاقات بينهم.

النتائج: توصلت الدراسة إلى أن التغير فى وضعية الرأس يؤثر على الإتزان الديناميكى وأيضا يؤثر على مدى الحركة لمفصل الكاحل عن طريق النسيج الضام الذى يربط بين كل أجزاء الجسم.