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Correlation between Forward Head Posture and Spinal Sagittal Balance

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Abstract

Background: Forward head posture and other forms of spinal sagittal imbalance at nowadays are a major cause of pain and disability among patients presenting to the spine clinic in daily practice. However, it is unclear if there are correlation between forward head posture and whole spinal balance or no therefore, the purpose of this study was to investigate the correlation between FHP and spinal sagittal balance.

Aim of Study: This current study was planned to measure the correlation between FHP and spinal sagittal balance.

Material and Methods: This study was carried at El-Sheikh Zayed Specialized Hospital out patient clinic of Physical Therapy. From December 2017 to April 2019. 30 subject aged between 25-35 years old from both sexes with radiological CVA <70◦ are included in this study, standard full-length lateral radiographs performed in all participant. FHP was assisted by CVA and we assess C7 plumb line for total spinal balance, Co-C2 angle for upper cervical lordosis, C2-C7 (SVA) and C2-C7 angle for lower cervical lordosis, T1 sagittal tilt, T4-T12 angle for thorathic kyphosis, L1-S1 angle for lumber lordosis and Sacral Slope (SS). Correlation analysis was used to identify the direction and strength of the relationship between forward head posture and spinal sagittal balance variables.

Results: Forward head posture angle is negatively strong correlated to C2-C7 SVA and has a negative intermediate correlation with T1 tilting and C0-C2 angle but it has aweak positive correlation with C7-S 1 SVA, on the other hand it has an no correlation with C2-C7 angle, sacral slope, lumber lordosis and thoracic kyphosis.

Conclusion: Increasing in forward head posture angle leads to increase in C7-S1 SVA and decrease in C2-C7 SVA, T1 tilting and C0-C2 angle. While it has no effect on C2-C7 angle, sacral slope, lumber lordosis and thoracic kyphosis.

Key Words: *Forward head posture – Sagittal balance – Full-length lateral radiographs.*

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Introduction

(FHP) is the structural forward positioning of the head away from the centerline of the body, where lower cervical vertebrae are bent and upper cervical vertebrae are extended, and the weight of the head supported by the neck is increased **[1]**. The bending moment of the head applies pressure on muscles and joints around the cervical vertebra, in addition to active myofascial trigger points of the suboccipital muscle which may induce tension type headaches, neck pain and cervical headaches, while reducing the mobility of the neck **[2]**.

Griegel-Morris et al., **[3]** stated that the FHP may affect not only neck but also the thoracic spine and shoulder blade, possibly causing overall imbalance in the musculoskeletal system, and also it is found that increased thoracic kyphosis has been thought to be one of the most frequently seen abnormalities in patients with lumbar lordosis **[4]**, low back pain **[5]**.

In a patient with normal sagittal balance, the center of the C7 vertebral body is in line with the posterior superior corner of S 1 and the longitudinal axis of the femur **[6]**. The main purpose of these lordotic and kyphotic spine segments is to balance the head over the pelvis in an energy-efficient position **[7-10]**. The casade of compensating mechanisms appears progressively with the increasing amount of imbalance of the spine until compensation is no longer possible and the individual is no longer able to keep the standing position **[11]**.

The only previous study for FHP and sagittal imbalance was done on cadaveric cervical spine to assess postural consequences of cervical sagittal imbalance **[12]**. And it was suggested to assess the whole spinal sagittal imbalance in FHP.

So the goal of this research work was to measure the correlation between FHP and spinal sagittal balance.

Subjects, Material and Methods

Design of the study:

Correlational study design.

Subjects: Thirty young adults from both sexes aged from 25-35 years old with Craniovertebral Angle (CVA) measured on X-ray less than or equal to 70º were participated in the study.

Selection of participants: Fristly, the CVA has been measured photographically and only subjects with CVA equal or less than 50º were admitted to X-ray examination. (Selection of 50 as a referance angle was guided by the study of Yib et al., **[13]** who reported 55:02±2:86 as anormal range and, as it well known, subjects with forward head had a significant smaller craniovertebral angle when compared with normal subjects.

Secondary, only participants with CVA less than or equal to 70º by radiological examination were participated in the study. Selection of 70 as a referance angle was guided by the study of Han-Kyu et al., **[14]** who found that on radiography values; CVA had 73º, CRA was 148º and Cobb was 50º of normal subject A and CVA had 70º, CRA was 150º and Cobb was 53º of FHP subject B and CVA had 61º, CRA was 153º and Cobb was 31º of FHP subject C.

Inclusion criteria:

Craniovertebral angle on X-ray less than or equal to 70º, age between 25 to 35 years old, the subjects recruited from the Physiotherapy Departments in Sheikh Zayed Specialized Hospital, all subjects have the same activity level and body mass index is 18-30kg/m^2.

Exclusion criteria:

Previous surgeries at spine, abdomen or shoulders, patients suffering from neurological manifestation, obesity (body mass index over 30kg/m^2), any spinal or lower limb deformity and subject with LBP.

1- *Instrumentation:*

- *Weight and height scale:* To measure weight and height.
- *Digital camera:* To have a lateral photo to evaluate CVA.
- *X-ray machine:* Toshiba X-ray machine, Model: RIP92154, S/N: 60511, made in Japane. To have standard full length lateral view X-ray scan to assess whole spinal balance. By Toshiba X-ray machine, Model: RIP92154, S/N: 60511, made in Japane.

Procedure of the study:

Frist, each subject was interviewed and personal information was collected and recorded. Subjects were assessed to make sure that they meet the inclusion criteria then subject's signature was taken in the consent form. The demographic data of each subject including the age, weight and height were measured and recorded.

Testing prosedure:

1- Photographic assessment of craniovertebral angle:

The craniovertebral angle was measured by taking a lateral photograph. The patients were asked to sit on a chair as usual and a lateral photograph was taken. A digital camera was positioned on a tripod at a distance of 0.8m from the subject. The axis of the lens of the camera was placed orthogonal to the sagittal plane of the patient at a height that corresponded with the seventh cervical vertebra. Adhesive markers were fixed on the tragus of the ear and the spinous processes of the seventh cervical vertebra. The head forward angle was measured as an angle between a line drawn from the tragus of the ear to the seventh cervical vertebra and horizontal line 15. If the angle was less than 50º or equal, then a participant was referred to the study.

2- Spinal sagittal balance:

Standard full-length lateral radiographs performed in all patients. The subject stands with both hips and knees fully extended, the elbows fully flexed, the wrists flexed with the hands in a relaxed fist placed into the supraclavicular fossa without any external support as the best patient position for the study of sagittal deformity resulting in the most accurate measurements and minimized repeated radiographic exposures. Sagittal balance is basically determined by the C7 plumb line. The mean C7 plumb line offset from the posterior-superior corner of S1 has been found to be 0.5cm. An offset >2.5cm anteriorly or posteriorly is considered to be abnormal. Thoracic kyphosis is measured from the superior endplate of T4 to the inferior endplate of T12 ranging between 10º to 40º **[16]**. Lumber lordosis angle is angle between L1 upper edge and L5 lower edge **[17]** usually ranging from 40º to 60º **[16]**. C0-C2 angle is the angle between the inferior endplates of C2 and McGregor's line (the line that connected the posterior margin of the

hard palate and foramen magnum) [18].This angle has an average value of 15.81º(±7.15º), always lordotic [19]. C2-C7 angle; angle between inferior end-plates of C2 and C7 [20]. Which is variable from kyphosis to lordosis in normal population [19]. CO-C2 and C2-C7 angles work inversely: When one is increasing, the other one is decreasing [19]. C2-C7 (SVA) is the distance between a plumb line dropped from the centroid of C2 and the posterior superior corner of C7. This value reflected the relative translation of the C2 vertebra against the C7 vertebra [20]. T1 slope is the angle between the line that was parallel to the superior end plate of T1 and the horizontal plane [20]. Sacral slope; the angle between the superior endplate of S 1 and a horizontal line extending from the anterior-inferior corner of the S 1 endplate [16].

Data and statistical analysis:

This section tackles the descriptive statistics for the main variables of the research including the relationship of FHP on spinal sagittal balance. In order to profile the research variables, arithmetic means, minimum, maximum values and standard deviation will be calculated using pearson correlation coefficient test.

Results

1- *General characteristics of subjects:*

Table (1) presents the descriptive statistical analysis for all variables. According to this analysis, the mean value of CVA is 60º and it takes values between 37º and 70º with 9 degree of standard deviation. The mean value of Sacral slope is 39º and it takes values between 26º and 52º with 7 degree of standard deviation.

Table (1): Descriptive analysis for all variables.

Main variables	Minimum	Maximum	Mean	Std. deviation
Sacral slope	26	52	39	7
Lumber lordosis	31	70	57	10
Thoracic kyphosis	24	60	40	9
T1 tilting	0	47	22	11
C7-S1 SVA	0	92	39	26
C2-C7 SVA	0	55	26	17
C2-C7 angle	6	51	17	9
C0-C2 angle	15	64	32	11
CVA	37	70	60	9

Testing the correlation between forward head posture and spinal sagittal balance:

This section attempts to provide an answer to the question in this study which is related to the type of the relationship between FHP as an independent variable and C0-C2 angle, C2-C7 angle, C2-C7 SVA, C7-S1 SVA, T1 tillting, thoracic kyphosis, lumber lordosis and sacral slope as dependent variables. This is through testing the hypothesis of this study which proposed that:

"*There was a significant correlation between forward head posture and spinal sagittal balance":*

Correlation analysis was used to identify the direction and strength of the relationship between FHP and spinal sagittal balance variables.

According to the results of Person's correlation coefficient (r) shown in (Table 2), there was a weak positive correlation between FHP and C2-C7 angle x (r=0.128, p=0.502) and lumber lordosis (r=0.071, p=0.710). There was a week negative correlation between FHP and C0-C2 angle (r= 0.319, p=0.085), sacral slope (r=–0.121, p=0.523), and thoracic kyphosis (r=–0.110, p=0.710). On the other hand, there was a negative intermediate correlation between FHP and T1 tilting (r=–0.520, p=0.003). The correlation between FHP and C7-S1 SVA was positive weak (r=0.362, p=0.050). But, there was a negative strong correlation between FHP and C2-C7 SVA (r=0.903, p=0.000).

Table (2): Correlation analysis between forward head posture and spinal sagittal balance.

Spinal sagittal balance variables	Correlation (r)	p-value
Sacral slope	–0.121	0.523
Lumber lordosis	0.071	0.710
Thoracic kyphosis	–0.110	0.564
T 1 tilting	–0.520**	0.003**
C7-S1 SVA	0.362**	0.050**
C2-C7 SVA	–0.903**	0.000**
C2-C7 angle	0.128	0.502
C0-C2 angle	–0.319	0.085

Referring to the previous (Table 2), FHP has a significant impact on T1 tilting, C7-S1 SVA and C2-C7 SVA since the p-values are less than 0.05. On the contrary, forward head posture (CVA) has insignificant effect on sacral slope, lumber lordosis, Thoracic kyphosis, C2-C7 angle and C0-C2 angle since the p-values are greater than 0.05.

Discussion

This study aimed at investigating the correlation between FHP and spinal sagittal balance presented by (C7 plumb line, T1 sagittal tilt, Co-C2 angle for, C2-C7 (SVA) and C2-C7 angle, thoracic kyphosis (T4-T12), lumber lordosis (L1-S1), Pelvic Tilting Angle (PTA), and Sacral Slope (SS) in middle age adults between 25-35 years old with (CVA) measured radiologicaly <70.

The cervical spine connects the skull and thoracic vertebrae and supports the mass of the head.

It is a multi-joint structure that allows complex movement of the neck. In recent years, many studies have used X-ray imaging to explore the relationship between parameters related to cervical sagittal alignment, involving the mass point of the head, C2 vertebral center, T1 slope, and other measurements. Lee et al., **[21]** found that T1 slope and C2-C7 Cobb angle were strongly correlated, whereas the cranial offset and C2-C7 Cobb angle were in moderate correlation. Nunez-Pereira et al., **[22]** found that the occiput-C2 angle and C2-C7 Cobb angle also showed a moderate correlation.

Kuan et al., **[18]** found that the CG-C7 SVA was found to be negatively correlated with C5-C7 angle and C2-C7 angle but not significantly correlated with C2-C5 angle. This result suggested that a forward shift of the head in the natural head position might indicate a loss of lordosis in the lower cervical spine. In this study we found that there is a significant negative intermediate correlation between FHP and T1 tilting. And also there is a significant negative strong correlation between FHP and C2-C7 (SVA), but FHP has insignificant effect on C2-C7 angle and C0-C2 angle. And since T1 was the fixed end of the cervical spine and the cervical column is influenced by the weight of the head, it is expected that the T1 slope might play a determining role in the curvature of the cervical spine. And found that T 1 slope was in positive correlation with C2-C7 angle **[21]**.

Avinash et al., **[23]**, found that patients with increased upper thoracic kyphosis and radicular symptoms may respond with increased FHP as a compensatory mechanism to increase their lower cervical neural foraminal area and alleviate nerve root compression. Forward head posture contorts the alignment of trunk on alignment from head to trunk by increasing kyphosis of thoracic bone as well as the neck bone. Attitude of neck maintains balance of neck muscles which is important to prevent musculoskeletal disorders. If the body continues to be in an improper position for long periods of time, some muscles remain in their stretched positions while others in their contracted positions. Inappropriate position forms knots in contracted muscle and weakness in elongated muscles. Improper position is such a condition in which the individual adapts altering the normal spinal alignment and natural curves of spine causing reduced lordosis of the lower cervical and kyphosis of the upper thoracic vertebrae. Thoracic kyphosis and lumbar lordosis are the most common ones among the several postural alterations **[24]**.

Drashti et al., **[25]** found that there is no significant association between FHP and alteration in spinal curvatures. The craniovertebral and cranial-rotational angle used to diagnose forward head posture showed significance with thoracic kyphosis and lumbar lordosis. The study showed 10% subjects had kyphosis and forward head posture and 25% subjects had kyphosis but no forward head posture. Many subjects with slight forward head posture have near normal posture. In our study we found that there is an insignificant correlation between (CVA), sacral slope, lumber lordosis and Thoracic kyphosis.

Conclusion:

Increasing in FHP angle leads to increase in C7-S1 SVA and decrease in C2-C7 SVA, T1 tilting and C0-C2 angle. While it has no effect on C2-C7 angle, Sacral slope, Lumber lordosis and Thoracic kyphosis.

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العلاقة بين الوضع الآمامى للرآس والإتزان السهمى للعمود الفقرى

تشكل وضعية الرآس الآمامية والآشكال الآخرى للخلل السهمى للعمود الفقرى سبباً رئيسياً للآلم بين المرضى الذين يقدمون إلى عيادات العلاج الطبيعى. ومع ذلك، فمن غير الواضح ما إذا كان هناك إرتباط بين وضعية الرآس الآمامية والتوازن الكلى للعمود الفقرى آو لا. لذلك فإن الغرض من هذه الدراسة هو التحقيق فى العلاقة بين الوضع الآمامى للرآس والإتزان السهمى للعمود الفقرى.

آجريت هذه الدراسة على ثلاثون شخصاً تتراوح آعمارهم بين ٢٥–٣٥ سنة من كلا الجنسين لديهم زاوية القحفى الفقرى آقل من ٧٠ درجة. وقد آجرى لهم تصوير شعاعى كامل الطول جانبى. ثم تم قياس زاوية القحفى الفقرى، الخط الرآسى للفقرة العنقية السابعة، زاوية الإنحناء بين قاعدة الجمجمة والفقرة العنقية الثانية، المحور العمودى السهمى بين الفقره العنقية الثانية والسابعة، زاوية الإنحناء بين الفقرة العنقية الثانية والسابعة، قياس الميل السهمى للفقرة الصدرية الآولى، زاوية الإنحناء بين الفقرة الصدرية الرابعة والثانية عشر، وزاوية الإنحناء بين الفقره القطنية الآولى والخامسة وزاوية الميل العجزى. تم إستخدام تحليل الإرتباط لتحديد إتجاه وقوة العلاقة بين الوضع الآمامى للرآس وقياسات العمود الفقرى السهمية المختلفة.

وقد وجد آن زاوية وضعية الرآس الآمامى ترتبط بشكل سلبى مع المحور العمودى السهمى بين الفقرة العنقية الثانية والسابعة ولها علاقة وسيطة سالبة مع الميل السهمى للفقرة الصدرية الآولى وزاوية الإنحناء بين قاعدة الجمجمة والفقرة العنقية الثانية ولكن لها علاقة إيجابية مع المحور العمودى السهمى بين الفقرة العنقية السابعة والفقرة العجزية الآولى ومن ناحية آخرى ليس لها علاقة مع زاوية الإنحناء بين الفقره العنقية الثانية والسابعة آو إنحناء الفقرات الصدرية آو إنحناء الفقرات القطنية وآيضاً زاوية الميل العجزى.

بناءاً على هذه النتائج فإن زيادة زاوية الوضع الآمامى للرآس تؤدى إلى زيادة المحور العمودى السهمى بين الفقرة العنقية السابعة والفقره العجزية الآولى ونقص المحور العمودى السهمى بين الفقره العنقية الثانية والسابعة، الميل السهمى للفقرة الصدرية الآولى، وزاوية الإنحناء بين قاعدة الجمجمة والفقرة العنقية الثانية. بينما لا يوجد لها تآثير على مع زاوية الإنحناء بين الفقرة العنقية الثانية والسابعة، إنحناء الفقرات الصدرية، إنحناء الفقرات القطنية، زاوية الميل العجزى.