Forward head posture does not affect sensorimotor function in healthy university students

ท่าทางศีรษะยื่นไปข้างหน้าไม่ส่งผลต่อการทำงานด้านการรับรู้และสั่งการในนักศึกษามหาวิทยาลัยที่มีสุขภาพดี

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ABSTRACT

Background: Forward head posture has been proposed to affect sensorimotor function. However, its effect on the cervical proprioceptive sense (JPS) and postural control remains unclear.

Objective: To determine whether forward head posture affects cervical joint position sense and standing balance in healthy university students.

Methods: 60 university students (30 with forward head posture and 30 with normal head posture), aged between 19 and 24, were included in this study. Forward head posture was screened by craniovertebral (CV) angle. The CV angle ≤ 48 degrees was considered as having a forward head posture. The cervical JPS was measured in cervical extension and rotation to the right and left sides, using a laser pointer attached to the head. Standing balance was measured using a sway meter under two conditions: narrow stance with eyes open and closed. The outcome measures were cervical joint position error (JPE), and postural sway area, and displacement in anteroposterior (AP) and mediolateral (ML) directions.

Results: There were no significant differences between groups for the cervical JPE in all directions (all $p > 0.05$). The total sway area and displacement in AP and ML directions during standing with eyes open and closed were not found to be different between both groups (all $p > 0.05$)

Conclusion: Forward head posture did not affect the cervical joint position sense and standing balance in healthy university students. This may suggest that forward head posture does not contribute to sensorimotor integration.

Keywords: CV angle, forward head posture, joint position sense, sensorimotor function, standing balance

บทคัดย่อ

ที่มาและความสำคัญ: ท่าทางของศีรษะยื่นไปข้างหน้าถูกพบว่ามีผลต่อการทำงานด้านการรับรู้และสั่งการ อย่างไรก็ตาม ผลกระทบของศีรษะยื่นไปข้างหน้าต่อการรับรู้ตำแหน่งของกระดูกสันหลังส่วนคอและการทรงท่ายังไม่ทราบชัดเจน

วัตถุประสงค์: เพื่อศึกษาผลของท่าทางของศีรษะยื่นไปข้างหน้าต่อการรับรู้ตำแหน่งของกระดูกสันหลังส่วนคอและการทรงตัวขณะยืนในนักศึกษามหาวิทยาลัยที่มีสุขภาพดี

วิธีการวิจัย: อาสาสมัครประกอบด้วยนักศึกษามหาวิทยาลัยจำนวน 60 คน (30 คนมีท่าทางของศีรษะยื่นไปข้างหน้า และ 30 คนมีท่าทางของศีรษะปกติ) ช่วงอายุระหว่าง 19 ถึง 24 ปี ท่าทางของศีรษะยื่นไปข้างหน้าถูกคัดกรองด้วยการวัดมุมการยื่นของคอ (craniovertebral angle, CV angle) โดยมุมการยื่นของคอ ≤ 48 องศาถูกพิจารณาว่ามีท่าทางของศีรษะยื่นไป

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ข้างหน้า การรับรู้ตำแหน่งของกระดูกสันหลังส่วนคอวัดโดยใช้เลเซอร์ที่ติดอยู่เหนือศีรษะในทิศทางเงยคอ และหมุนคอไปทางด้านซ้ายและขวา การทรงตัวขณะยืนวัดโดยใช้อุปกรณ์วัดการแกว่งของร่างกาย (sway meter) ใน 2 เงื่อนไข คือ ยืนเท้าชิดพร้อมกับลืมตาและหลับตา ตัวแปรที่วัด ได้แก่ ความคลาดเคลื่อนของการรับรู้ตำแหน่งของคอ และพื้นที่การแกว่งของร่างกายและระยะการแกว่งของร่างกายในทิศทางด้าน-หลัง และซ้าย-ขวา

ผลการวิจัย: ไม่พบความแตกต่างอย่างมีนัยสำคัญระหว่างกลุ่มของความคลาดเคลื่อนของการรับรู้ตำแหน่งของคอในทุกทิศทาง (ทั้งหมด $p > 0.05$) พื้นที่ของการแกว่งของร่างกายและการแกว่งของร่างกายในทิศทางด้านหน้า-หลัง และซ้าย-ขวา ขณะยืนลืมตา-หลับตา ไม่ถูกพบความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างสองกลุ่ม (ทั้งหมด $p > 0.05$)

สรุปผล: ท่าทางศีรษะยื่นไปข้างหน้าไม่มีผลต่อการรับรู้ตำแหน่งของกระดูกสันหลังส่วนคอและการทรงตัวในท่ายืนในนักศึกษามหาวิทยาลัยที่มีสุขภาพดี ผลการศึกษานี้อาจจะแสดงให้เห็นว่าท่าทางศีรษะยื่นไปข้างหน้าไม่ได้ส่งผลต่อการประมวลผลของระบบการทำงานของการรับรู้และการสั่งการ

คำสำคัญ: มุม CV ท่ายื่นศีรษะไปทางด้านหน้า การรับความรู้สึกตำแหน่งของข้อต่อ การทำงานร่วมระหว่างการรับความรู้สึกและการสั่งการ การทรงตัวในท่ายืน

Introduction

Forward head posture is usually defined as resting head posture held in front of the line of gravity with the eyes level or angled downwards in upright position[1]. Its incidence varies from 66% to 85% in healthy individuals[2]. There is evidence that forward head posture produces a compressive force on the cervical spine[3]. Thus, forward head posture is suggested to be associated with neck pain[4], although good quality evidence to support its association remains unclear[5]. Additionally, the forward head posture often coexists with rounded shoulders and increased thoracic kyphosis[6]. A study demonstrated that forward head posture mediated the relationship between thoracic kyphosis and cervical range of motion, particularly in rotation and flexion[7].

It has been proposed that forward head posture affects the sensorimotor system responsible for joint proprioception and balance control.[8, 9] Cervical muscles, specifically deep layers, provide support and stability to the cervical spine.[10] The deep cervical muscles are shown to have a high density of muscle spindles providing proprioceptive information for the sensorimotor system.[11, 12] Performance of cervical flexor and extensor muscles was associated with forward head posture in healthy individuals.[13] There is evidence that forward head posture can alter cervical afferent input to the central nervous system, resulting in impaired sensorimotor integration.[8, 9] A delay in the onset of cervical flexion-relaxation phenomenon following static flexion was also found in healthy subjects.[8] Dysfunction of cervical flexor and extensor muscles associated with forward head posture may therefore result in altered cervical mechanoreceptors, leading to impaired cervical joint position sense. Additionally, a recent study has demonstrated that young healthy computer workers who spent > 6 hours/day working at a computer had a more pronounced forward head posture, a more anterior center of gravity, and poorer balance performance compared with those

who spent < 1 hour/day working at a computer.[14] This result may suggest that forward head posture contributes to a disturbance in balance during standing. However, Silva et al. [15] in contrast, found that an induced forward head posture did not affect postural control in healthy university students. The authors discussed that one possible reason might be associated with a period of forward head posture. Another reason might be due to that the postural control system of young healthy participants could adapt to the challenges imposed by exaggerated forward head posture. According to the association of the cervical afferent input and sensorimotor system, forward head posture on cervical proprioceptive sense and postural control should be further explored. Thus, the present study aimed to determine whether forward head posture affects cervical joint position sense and standing balance in healthy individuals.

Methods

Participant

Sixty university student volunteers (30 with forward head posture and 30 without forward head posture), aged between 19 and 24, were enrolled in the study. University students were chosen based on the assumption of a comparatively homogenous population. All participants were recruited through advertisements on Facebook and flyers on university campuses located in Chiang Mai. Exclusion criteria were dizziness, neck and shoulder pain, any musculoskeletal problems/conditions that could affect outcomes (e.g., back pain, ankle pain, and myofascial pain), vestibular disorders, and non-athletes.

Participants were made an appointment with a blinded assessor for assessment of forward head posture. Forward head posture was measured by craniovertebral (CV) angle with a digital camera (Canon EOS 600D) in a natural sitting position.[16] The CV angle was defined as the intersection of a line drawn from the tragus of the ear to the C7 spinous process and a horizontal line passing through the C7 spinous process[17] (Figure 1). The head posture was measured twice in a lateral view with the right side of the participant photographed. The CV angle of each photograph was measured twice in degrees using the Image J program, and an average value was used for determining forward head posture. Participants who had a CV angle ≤ 48 degrees were considered to have a forward head posture, and those with a CV angle (> 48 degrees) were considered to have a normal head posture.[18] In this study, intra-rater reliability of the CV and SH measurements was performed in 15 university students, and the results were excellent ($ICC_{3,1}$ = 0.91 and 0.85, respectively)

Outcome measures

- *Cervical joint position sense (JPS) test*

Cervical JPS test was measured using a laser pointer attached to the head described by Revel et al.[19] Participants sat on a chair with the head in a neutral position, 90 centimeters away from the center of a target attached on a wall. Participants were asked to close their eyes and perform an active cervical movement and return as accurately as possible to the starting position.

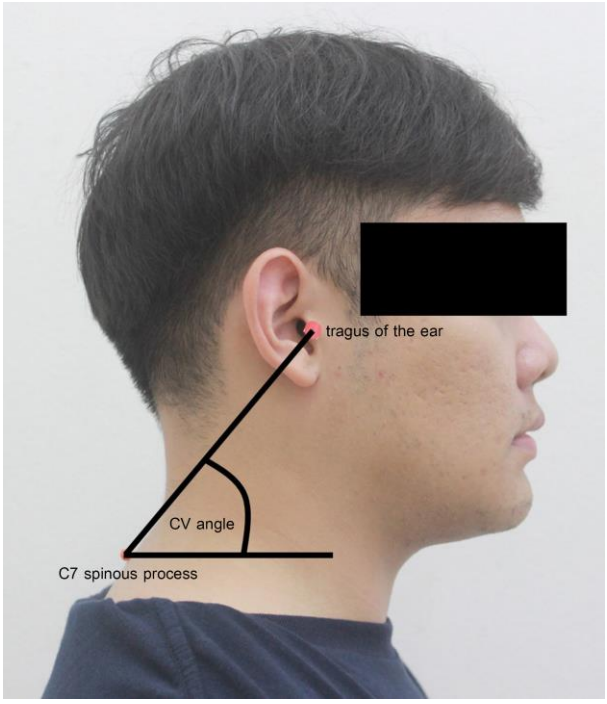

Figure 1 Measurement of CV angle

The cervical JPS was tested in cervical extension and rotation to the right and left directions in random order. Each direction was measured three times. The participant's head was repositioned back to the starting position by the examiner before the beginning of each trial. No verbal feedbacks were given during the testing. An absolute joint position error (JPE) was calculated from the final laser position and the starting position for each trial. An average value of the JPE for three trials of each movement was used for analysis.

- *Standing balance test*

A sway meter was used to measure static standing balance, according to previous studies.[20, 21] The sway meter comprised a 40-cm-long rod with a vertically mounted pen at its end attached to a belt. It was attached to participants at their waist levels with a rod extending posteriorly (Figure 2). Participants were asked to stand barefoot with their feet together (narrow stance) under two different conditions in a standardized order: 1) eyes open, and 2) eyes closed.[15] Participants were instructed to stand as still as possible for 30 seconds for each condition. Each condition was measured once, and a 10-second rest was allowed between each condition. The pen recorded the participant's postural sway on a millimeter graph paper fastened to the top of an adjustable-height table. The displacement in the maximum anterior-posterior (AP) and medial-lateral (ML) directions and a total sway area were calculated by the number of millimeter squares traversed by the pen.

Figure 2 Standing balance measure using a sway meter

- *Study procedure*

Participants were screened for the exclusion criteria and by measuring the CV angle.

Participants were divided into two groups: forward head posture (CV angle ≤ 48 degrees) and normal head posture (CV angle > 48 degrees). The tests were measured in a fixed order as follows: cervical JPS and standing balance. Five-minute intervals were given between the JPS and standing balance tests. All tests were performed by an examiner who was blinded to the participants' group.

This study was approved by the ethical review committee for research in humans, Faculty of Associated Medical Sciences, Chiang Mai University (AMSEC-61EX-085). All participants provided written informed consent before the commencement of the study.

Statistical analysis

Descriptive statistics and independent t-test were used to determine the demographic characteristics of participants. Shapiro-Wilk test was used to analyze the normality of the outcome variables. An independent t-test was used to analyze differences in the cervical JPE and the sway area and displacements between groups. The level of significance was set at 0.05.

Results

Demographic characteristics for the participants are presented in Table 1. The CV angle was less in the forward head posture group than the normal head posture group ($p < 0.01$). There were no between-group differences in other characteristics of participants, including duration of sitting during studying and duration of smartphone use (all $p > 0.05$).

The cervical JPE values in extension and rotation (left and right) and the sway area and displacement in AP and ML directions for the forward head posture and normal head posture groups are provided in Table 2. There were no significant differences in the cervical JPE in all directions between groups (all $p > 0.05$). The total sway area and displacements during standing with eyes open and closed were not found to be different between both groups (all $p > 0.05$) (Table 2).

Table 1 Demographic characteristics of the participants

Variables	Forward head posture (n = 30)	Normal head posture (n = 30)	p-value
Age (yrs.)	22.07 ± 1.31	21.80 ± 1.58	0.48
Gender (% female)	70.00	60.00	0.43
Height (cm.)	162.97 ± 8.16	165.28 ± 10.63	0.35
Weight (kg.)	60.47 ± 11.27	58.64 ± 11.41	0.53
Duration of sitting during studying (hrs.)	6.10 ± 2.19	6.43 ± 2.75	0.61
Duration of smartphone use (hrs.)	8.08 ± 3.36	8.23 ± 3.97	0.86
CV angle (degree)	44.67 ± 2.47	51.54 ± 2.95	0.01*

Note: yrs. = years, cm. = centimeters, kg. = kilograms, hrs. = hours, CV angle = craniovertebral angle, * p-value < 0.05

Table 2 Outcome variables between the forward head posture and normal posture groups (mean ± sd)

Variables	Forward head posture (n = 30)	Normal head posture (n = 30)	Mean difference 95% confidence interval	p-value
JPE (degrees)				
- extension	3.28 ± 1.50	3.39 ± 2.23	0.10 (-0.89 to 1.08)	0.84
- rotation to the left	3.79 ± 1.57	3.83 ± 1.35	0.03 (-0.72 to 0.79)	0.93
- rotation to the right	3.22 ± 1.72	3.47 ± 1.41	0.25 (-0.57 to 1.06)	0.55
Postural sway				
● eyes open				
- AP displacement (cm.)	1.95 ± 0.83	1.90 ± 0.65	-0.05 (-0.43 to 0.33)	0.79
- ML displacement (cm.)	1.84 ± 1.10	1.63 ± 1.12	-0.22 (-0.79 to 0.36)	0.45
- total area (cm^2.)	8.20 ± 3.47	8.06 ± 4.32	-0.14 (-2.16 to 1.89)	0.89
● eyes closed				
- AP displacement (cm.)	2.27 ± 0.83	2.12 ± 0.81	-0.15 (-0.57 to 0.27)	0.48
- ML displacement (cm.)	1.73 ± 1.01	1.95 ± 1.03	0.22 (-0.31 to 0.74)	0.41
- total area (cm^2.)	9.52 ± 4.59	10.18 ± 5.09	0.66 (-1.84 to 3.16)	0.60

Note: JPE = joint position error, AP = anterior-posterior, ML = medial-lateral, cm. = centimeters, cm^2. = square centimeters

Discussion

This study demonstrated that forward head posture did not affect the cervical joint position sense and standing balance in healthy university students. There were no differences in the cervical JPE values and sway area and displacement in AP and ML directions between the participants with forward head posture compared to controls with normal head posture. Knowingly, the cervical muscles play an important role in head and neck posture as well as provide proprioceptive information, which is an essential component of sensorimotor function. Thus, it was expected that changes in head and neck posture (forward head posture) would disturb cervical joint position sense and standing balance. The results of this study do not support other previous studies suggesting that forward head posture and static neck flexion could lead to changes in the cervical proprioception and affected sensorimotor integration.[8, 9] Additionally, the results of this study are inconsistent with a recent study suggesting that forward head posture during computer-based work (> 6 hours/day) might contribute to some disturbance in the balance of healthy adults.[14] The discrepancy of the previous and our findings may be due to differences in participant characteristics and methodological approaches. This study investigated university students with and without forward head posture, using a sway meter. In contrast, Kang et al. [14] investigated subjects who worked with computers for over 6 hours per day compared to those who rarely worked with computers, using computerized dynamic

posturography. However, no impaired standing balance observed in our participants with forward head posture is consistent with the findings of Silva et al.'s study investigating balance in young university students when they were in their natural head posture and when they were required to perform an exaggerated forward head posture.[15] Silva et al. [15] found that induced forward head posture did not affect postural control. Although there is evidence suggesting that persons with forward head posture had reduced cervical range of motion[22] and impaired cervical muscle performance, it is possible that forward head posture is not enough to alter cervical proprioceptive information and impaired sensorimotor function. The ability to maintain balance involves cervical proprioception and sensory information from visual, vestibular, and somatosensory systems and musculoskeletal system.[23,24] Thus, balance in those with forward head posture may rely on or be compensated by the other systems. Alternatively, it may be due to severity and a period of forward head posture occurred, which is yet to be answered in this and the previous studies.[15]

Regarding the cervical JPS, the results of this study showed no differences in the cervical JPE between those with and without forward head posture. As the present study was the first study investigating the influence of forward head posture on the cervical JPS, no previous findings of JPS are available for comparison. Nonetheless, Dolan and Green[25] found a significant increase in lumbar joint repositioning error after 5 minutes in a slouched posture. The cervical proprioceptive system consists of mechanoreceptors in the capsule, muscle, ligament, and joint around the cervical spine. The mechanoreceptors in such structures can be disturbed by several factors, including pain, injury, and dysfunction.[26, 27] Forward head posture has been suggested to be associated with an increase in the compressive forces to the cervical structures, including apophyseal joints, ligaments, and posterior neck structures.[3] The JPS test in this study might not be challenging enough. On the other hand, it may be due to severity and a period of forward head posture. Therefore, further studies are still needed to confirm our findings and investigate JPS in different populations, for example, in persons with neck pain with and without forwarding head posture.

There are some limitations to this study. Participants recruited into the study were university volunteers aged range 19-24 years. This potentially limits the generalizability of the study's results to other populations. Additionally, this study focuses on the sensorimotor system, a subcomponent of a comprehensive motor control system, and yet targets through the sensory, motor, and central integration components. Thus, this issue should be addressed in future research. Further studies should also investigate sensorimotor function in different groups of populations with forward head posture and persons with neck pain associated with forward head posture. Additionally, more challenging tests of the balance (e.g., dynamic standing balance and gait) and JPS (e.g., neck torsion and en bloc) should be included in further studies.

Conclusion

Forward head posture did not affect the cervical joint position sense and standing balance in healthy university students. This suggests that forward head posture may not contribute to sensorimotor integration.

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