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Comparison of Thoracic Reposition Error in Individuals With or Without Habitual Slouched Posture

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Abstract

In this study, we present the difference in thoracic reposition sense in young people (24.00 ±2.20 years old) with and without habitual slouched posture in two target positions of half flexion and half extension. People with habitual slouched posture (n = 20; 11 men and 9 women) and people without slouched posture (n = 20; 10 men and 10 women) were recruited from three universities. Thoracic spine (T-spine) repositioning errors were measured in two target positions (half flexion and half extension). People with habitual slouched posture showed significantly higher thoracic repositioning error in the extension target position than did people without slouched posture (P<0.05). There was no difference in repositioning error in the flexion target position between the two groups (P>0.05). In conclusion, people with habitual slouched posture show lower T-spine repositioning sense in extension than do people without slouched posture. A rehabilitation program to treat habitual slouched posture, such as postural correction education, should be implemented for individuals with decreased position sense of the T-spine.

***Key Words**: Proprioception, Reposition Sense, Habitual Slouched Posture, Thoracic Spine*

1. Introduction

T-spine pain, which is pain experienced in the region of the upper back or middle back between the boundaries of T-spine 1 and T-spine 12, has received less attention in terms of research and review than have cervical and lumbar spine pain [1, 2]. Mechanical thoracic pain is usually the result of cumulative microtrauma caused by abnormalities in posture and movement patterns [3, 4]. Sahrmann (2002) suggested that repeated movements and sustained postures can lead to adaptations in muscle length, strength, and stiffness; in turn, these adaptations may result in movement impairments. Habitual slouched posture is associated with movements and postures that increase the flexion curvature not only the lumbar spine but the thoracic spine, commonly resulting in alignment impairment of thoracic kyphosis and posterior trunk sway [5-7]. Excessive and sustained thoracic flexion leads to lengthening of the thoracic paraspinal muscles and biomechanical stress that can cause musculoskeletal pain in the T-spine region [8-10]. People who maintain prolonged thoracic flexion may have pain or difficultly when attempting to decrease the thoracic curve and are usually unable to correct their alignment [6]. High degrees of thoracic flexion can increase thoracolumbar disc loading, flexion moment,

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compression, and shear force and is associated with head posture and compensatory changes in the more mobile lumbar and cervical regions [4, 11-13].

To correct habitual slouched posture, the patient should actively revise the alignment and maintain this correction within the optimal range of motion while avoiding excessive flexion during all activities and exercise. Postural control requires a complex interaction of the musculoskeletal and neuromuscular systems. However, lengthened paraspinal muscles due to a prolonged flexed posture should slacken and unload the spindle, decreasing resting spindle discharge on the return to an intermediate reposition and altering velocity sensitivity [14-17, 18]. Although the T-spine has a greater flexion moment than the lumbar spine [19], most research has only investigated whether prolonged flexion of the lumbar spine affects postural control and alters muscle response; there is no information on whether excessive and habitual thoracic flexion is associated with muscle and ligament laxity or with a poor postural control mechanism.

Therefore, the primary aim of the present study was to compare the thoracic reposition sense of people with and without habitual slouched posture during thoracic half-flexion and half-extension tasks to understand how habitual trunk hyperflexion affects proprioception of the T-spine in the sagittal plane. Investigating changes in proprioception in individuals with habitual slouched posture will provide beneficial information to clinicians in terms of designing and implementing treatment protocols.

2. Experimental Methods

2.1 Participants

As shown in Table 1, twenty people with habitual slouched posture and 20 healthy people were selected from among 250 young people in three universities in South Korea. Twenty age- and sex-matched participants with mean kyphotic angle were selected as the control group. These participants reported no instance of low back or thoracic pain within the last year or musculoskeletal disorders that would limit normal thoracic flexion.

Table 1. Characteristics of the study sample

Characteristics	Experimental group (n = 20)	Control group (n = 20)	p
Men	11	10	
Women	9	10	
Age (years)	24.00 (±2.20)	24.00 (±2.20)	.89
Height (cm)	171.00 (±8.50)	171.00 (±6.20)	.90
Weight (kg)	66.20 (±13.69)	59.60 (±8.62)	.08
BMI (kg/m^2)	22.43 (±2.61)	20.39 (±1.62)	.01*

*$p < 0.05$

2.2 Apparatus and Experimental Procedure

2.2.1 Clinical Evaluation of Habitual Slouched Posture

A dual inclinometer (JTECH Medical, Suite G Salt Lake City, UT, USA) was used to measure the T-spine angle. The spinous processes of T-spine 1 and T-spine 12 were used as landmarks [20]. The thoracic kyphosis angles were obtained in four conditions: sitting, standing at attention, standing with shoulders in full flexion, and the quadruped position [5]. A general goniometer was used to measure the infrasternal angle, which is the angle between the seventh costal cartilages in the supine position.

2.2.2. T-spine Reposition Tests

As shown in Figure 1, all subjects performed the same test for assessment of thoracic repositioning acuity: the hips and knees were positioned at 90°, both forearms were crossed over the chest, and the feet were positioned 20 cm apart [21]. To measure the thoracic movement, a flexible electrogoniometer (FEG) (BIOPAC Systems, Inc., Santa Barbara, CA, USA) was used. After zeroing, the FEG end blocks were secured 12 cm above and below the T6–T7 interspinous space with double-sided self-adhesive tape [22]. T-spine movement data were recorded by MP150WSW (BIOPAC Systems, Inc., Santa Barbara, CA, USA) and analyzed at a frequency of 100 Hz using Acqknowledge 4.1 software.

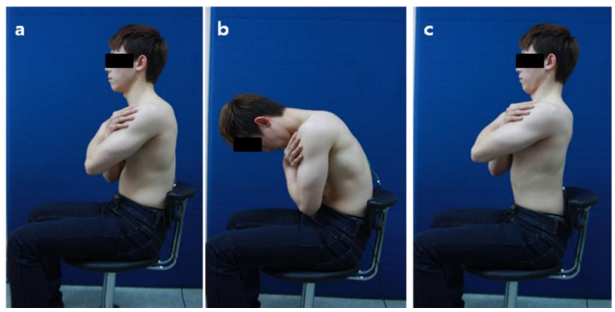

Figure 1. Measurements of the degree of movement. T_{neu} (a), T_{flex} (b), and T_{ext} (c).

After the subjects were asked to stand up and sit down twice, the last sitting posture was recorded as a neutral sitting posture, and the angle was defined as a neutral thoracic angle (T_{neu}) [21]. The subjects were asked to repeat each maximal thoracic flexion (T_{flex}) and extension (T_{ext}) twice based on their abilities, and the thoracic angle was measured in each position. The mean T-spine angles in flexion and extension were designated T_{flex} and T_{ext}. The target angles for the repositioning were set at half flexion (TP_{flex}) on the way toward T_{flex} from T_{neu} in equation (1) and at half extension (TP_{ext}) on the way toward T_{ext} from T_{neu} in equation (2).

$$TP_{flex} = T_{neu} + 1/2 \times (T_{flex} - T_{neu}) \quad (1)$$
$$TP_{ext} = T_{neu} - 1/2 \times (T_{neu} - T_{ext}) \quad (2)$$

During the single trial to measure the reposition sense of the thoracic spine, subjects had to perform a standardized thoracic flexion–extension movement in three phases: examiner's guide phase (the examiner guided the subject to the target position and he/she had to memorize the position for 2 s), neutral phase (the subject was instructed on T_{neu}), and repositioning phase (the subject had to return to the target position as closely as possible, at which point he/she gave a verbal signal indicating "yes" and held the position for 2 s). This position was indicated as the matching position (MP). After the six practice trials to familiarize, 10 assessment trials were performed in each TP with no verbal or visual feedback during this session. To eliminate order effects, the TP_{flex} and TP_{ext} tests were performed in random order, and subjects were asked to rest for 5 min before performing the next reposition sense protocol.

2.3. Data Analysis

Reposition sense error was defined as the absolute error that was defined as the absolute value of the difference (in degrees) between the target thoracic angle (TPi) and the actual thoracic angle reproduced by the subjects (MPi) in equation (3).

$$\text{Absolute error} = \sum_1^{10} |TPi - MPi| \quad (3)$$

An unpaired t-test was used to compare the thoracic kyphosis angles in the four positions, the infrasternal angle in the supine position, and the absolute errors in each TP_{flex} and TP_{ext} task in the group with habitual slouched posture and the control group. Analyses were undertaken using the Statistical Package for the Social Sciences (SPSS version 23), and a *p*-value of <0.05 was deemed statistically significant.

3. Results

3.1 Clinical Evaluation of Habitual Slouched Posture

Compared with the control group, subjects with habitual slouched posture had significantly higher kyphotic angles in sitting posture (32.85° ± 5.86° vs. 23.60° ± 6.03°, $p < 0.001$). The subjects with habitual slouched posture had significantly higher kyphotic angles in the standing-at-attention posture (44.30° ± 4.85° vs. 30.00° ± 4.80°, $p < 0.001$), standing with shoulders in flexion (31.30° ± 7.34° vs. 21.00° ± 7.10°, $p < 0.001$), and the quadruped posture (32.05° ± 11.01° vs. 20.10° ± 11.59°, $p < 0.001$). Furthermore, the infrasternal angle was significantly higher (p = 0.036) in subjects with habitual slouched posture (90.45° ± 10.37°) than that in the control group (84.00° ± 8.32°).

3.2 Comparison of Thoracic Reposition Sense in Subjects with and without Habitual Slouched Posture

As shown in Figure 2, the thoracic reposition sense error in the habitual slouched posture group was significantly higher than that in the control group in TP_{ext} (18.98° ± 13.06°, 11.11° ± 5.72°; p = 0.02), but there was no difference in TP_{flex} between the two groups (12.43° ± 5.03°, 12.35° ± 8.8°; p = 0.97).

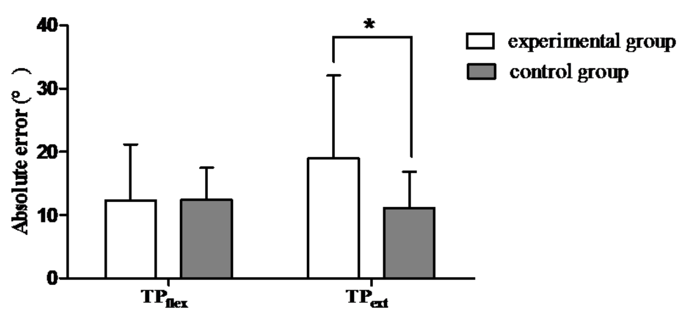

Figure 2. Thoracic reposition error in individuals with and without habitual slouched posture during TP_{flex} and TP_{ext} tasks (*p < 0.05).

4. Discussion

The purposes of the current study were to measure the T-spine angle in the various position and infrasternal angle of people with habitual slouched posture and to examine differences in the reposition sense of the T-spine between groups during T-spine flexion and extension tasks. The results of this study showed that compared with the control group, the thoracic kyphotic angle of the habitual slouched posture group was significantly higher not only sitting but also standing at attention, standing with shoulders flexed, and the quadruped position ($p < 0.001$) besides the infrasternal angle was higher in the this group ($p = 0.036$). Additionally, the habitual slouched posture group showed significantly higher T-spine reposition error than the control group in the thoracic extension task; however, there was no difference in the thoracic flexion task between the two groups.

Many researchers consider the thoracic flexion posture, to be particularly associated with various musculoskeletal syndromes [6, 13, 23]. Our results support that an increased flexion angle while standing and sitting in the habitual flexed posture group had an impact on most daily activities, with the exception of sleeping. Increased thoracic flexion not only causes pain or movement impairment syndrome in the thoracic and lumbar spine area but is also associated with a forward head posture [13, 24], osteoporotic compression fracture of the spine [3]. Habitual flexed posture potentially has a high risk for the development of these musculoskeletal diseases. Therefore, correction of alignment and movement from a flexed posture to the normal range is essential in this people. However, the habitual flexed posture group showed significantly decreased T-spine position sense, especially in the extension direction. Although the cause of reduced reposition sense in the T-spine has not been previously studied, some conclusions can be drawn based on studies of the lumbar spine or thoracolumbar area. First, history-dependent kinesthetics may affect proprioception. A lengthening history unloose intrafusal fiber, viscous component by increasing interfilamentary distance, so thixotropic change and affects to γ-motor neuron derive to reduce muscle spindle excitability [17-18, 25]. Additionally, prolonged or repetitive thoracic flexion influences intervertebral ligament laxity because of tissue creep and stress–relaxation effects, affects large mechanoreceptors, and changes the reflex response [24]. As the lengthening history is prolonged, lumbar spine repositioning accuracy is reduced [16]. A prolonged or repetitive thoracic flexion position during day-to-day activity lengthens the posterior viscous structures in people with slouched position, and sensitivity to repositioning following a prolonged lengthening history is diminished in the thoracic spine. However, in this study, there was a significant difference in the reposition error in the direction of the flexion target position because a flexed the T-spine does not influence the lengthening or stretching of the anterior structures of thoracic spine, such as muscles and ligaments.

In this study, people with slouched position has wide subcostal margin. It may be present shortened rectus abdominal muscle and lengthened external oblique muscle, so poor abdominal control would be observed that increased recruitment of rectus abdominal muscle over the external oblique muscle [9]. The thoracic flexion posture is closely associated with alignment and direction of movement correction in this people. Sahrmann discussed directional susceptibility to movement (DSM) with reference to movement system balance [5]. DSM is a compensatory movement in a specific direction or a stress applied in a specific direction that is related to the site of pain and causes movement impairment syndromes [5]. According to this theory, the more a flexed position of the spine is repeated or prolonged over time, the more thoracic kyphosis is increased, leaving flexion-affected individuals in a vicious circle.

The slouched position associated with sitting during office work, studying, and computing is increased in young people. Early diagnosis and later postural correction education are necessary in such cases. Our findings suggest the utility of these simple clinical evaluation methods and criteria for habitual flexed posture. Additionally, postural correction education requires special care to prevent compensation, such as increased lumbar lordosis, because people with habitual flexed posture in this study had lower proprioception than did the control group in the T-spine in extension. A limitation of this study is that there were no radiological data to determine the difference in the thoracic kyphotic angle between the habitual flexed posture and control group. Although the use of a dual inclinometer is a reliable and valid technique [19, 26], the Cobb or modified Cobb method is the gold standard for measuring thoracic kyphosis.

5. Conclusion

In the present study, we found that people with habitual flexed posture who had increased thoracic kyphotic angle and infrasternal angle had a diminished reposition sense in the extension, but not in the flexion, direction.

This would make the task of extending the trunk from a slouching position an exceedingly difficult one. As the flexion position of the T-spine is repeated or prolonged, it could enter a vicious circle of more increased thoracic kyphosis. Variations in the thoracic flexion posture are associated with compensatory changes in the head posture and lumbar spine. Consequently, it could reinforce musculoskeletal disorders not only of the T-spine but also of the lumbar and cervical spine and shoulder complex. New methods or studies, such as controlled exercise, taping, and the use of monitoring equipment, will allow for the correction of habitual or functional thoracic flexion posture. Future studies using radiological data for recruitment of participants will be needed.

References

[1] A. M. Briggs et al., "Prevalence and Associated Factors for Thoracic Spine Pain in the Adult Working Population: A Literature Review," Journal of Occupational Health, Vol. 51, No. 3, pp. 177-192, Apr 2009. DOI: https://doi.org/10.1539/joh.K8007

[2] M. Comerford, and S. Mottram, Kinetic control: the management of uncontrolled movement, Elsevier, 2012.

[3] A. M. Briggs et al., "Thoracic kyphosis affects spinal loads and trunk muscle force," Physical Therapy, Vol. 87, No. 5, pp. 595-607, May 2007. DOI : https://doi.org/10.2522/ptj.20060119

[4] S. J. Edmondston, and K. P. Singer, "Thoracic spine: anatomical and biomechanical considerations for manual therapy," Manual Therapy, Vol. 2 No. 3, pp. 132-143, Aug 1997. DOI: https://doi.org/10.1054/math.1997.0293

[5] S. A. Sahrmann, Diagnosis and treatment of movement impairment syndromes, Mosby, 2002.

[6] S. A. Sahrmann, Movement system impairment syndromes of the extremities, cervical and thoracic spine, Mosby, 2010.

[7] S. O. Hwang, B. G. An, and I. H. Jee, "Development of Posture Correction Cushion based on Programmable Robot," The Journal of the institute of Internet, Broadcasting and Communication, Vol. 12, No. 4, pp. 43-49, Aug 2012. DOI https://doi.org/10.7236/JIWIT.2012.12.4.43

[8] S. J. Edmondston et al., "Thoracic spine extension mobility in young adults: influence of subject position and spinal curvature," Journal of Orthopaedic & Sports Physical Therapy, Vol. 41, No. 4, pp. 266-273, Apr 2011. DOI: https://www.jospt.org/doi/10.2519/jospt.2011.3456

[9] S. D. Ryan, and L. P. Fried, "The impact of kyphosis on daily functioning," Journal of the American Geriatrics Society, Vol. 45, No. 12, pp. 1479-1486, Dec 1997. DOI: https://doi.org/10.1111/j.1532-5415.1997.tb03199.x

[10] G. L. Kim, K. S. Hwang, and Y. S. Nam, "Assessment of the Posture Function by Hand Movement," The Journal of the institute of Internet, Broadcasting and Communication, Vol. 14, No. 5, pp. 131-135, Oct 2014. DOI https://doi.org/10.7236/JIIBC.2014.14.5.131

[11] D. E. Harrison et al., "Anterior thoracic posture increases thoracolumbar disc loading," European Spine Journal, Vol. 14, pp. 234-242, Apr 2005. DOI: https://doi.org/10.1007/s00586-004-0734-0

[12] K. T. Lau et al., "Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability," Manual Therapy, Vol. 15, No. 5, pp. 457-462, Oct 2010. DOI: https://doi.org/10.1016/j.math.2010.03.009

[13] I. Zepa et al., "Associations between thoracic kyphosis, head posture, and craniofacial morphology in young adults," Acta Odontologica Scandinavica, Vol. 58, No. 6, pp. 237-242, 2000. DOI: https://doi.org/10.1080/00016350050217064

[14] M. W. Olsen, L. Li, and M. Solomonow, "Flexion-relaxation response to cyclic lumbar flexion," Clinical Biomechanics, Vol. 19, No. 8, pp. 769-776, Oct 2004. DOI: https://doi.org/10.1016/j.clinbiomech.2004.05.007

[15] M. W. Olsen, L. Li, and M. Solomonow, "Interaction of viscoelastic tissue compliance with lumbar muscles during passive cyclic flexion-extension," Journal of Electromyography and Kinesiology, Vol. 19, No. 1, pp. 30-38, Feb 2009. DOI: https://doi.org/10.1016/j.jelekin.2007.06.011

[16] K. J. Dolan, and A. Green, "Spine reposition sense: the effect of a 'slouched' posture," Manual Therapy, Vol. 11, No. 3, pp. 202-207, Aug 2006. DOI: https://doi.org/10.1016/j.math.2006.03.003

[17] W. Ge and J. G. Pickar, "Time course for the development of muscle history in lumbar paraspinal muscle spindles arising from changes in vertebral position," The Spine Journal, Vol. 8, No. 2, pp. 320-328, Mar-Apr 2008. DOI: https://doi.org/10.1016/j.spinee.2007.05.009

[18] D. Y. Cao, and J. G. Pickar, "Lengthening but not shortening history of paraspinal muscle spindles in the low back alters their dynamic sensitivity," Journal of Neurophysiology, Vol. 105, No. 1, pp. 434-441, Jan 2011. DOI: https://doi.org/10.1152/jn.00498.2010

[19] D. A. Neumann, Kinesiology of the musculoskeletal system: foundations for physical rehabilitation (2nd ed.), Mosby, 2009.

[20] J. S. Lewis, and R. E. Valentine, "Clinical measurement of the thoracic kyphosis. A study of the intra-rater reliability in subjects with and without shoulder pain," BMC Musculoskeletal Disorders, Vol. 11, pp. 39-46, Mar 2010. DOI: https://doi.org/10.1186/1471-2474-11-39

[21] M. Å sell, P. Sjöander, H. Kerschbaumer and M. Djupsjöbacka, "Are lumbar repositioning errors larger among patients with chronic low back pain compared with asymptomatic subjects?," Archives of Physical Medicine and Rehabilitation, Vol. 87, No. 9, pp. 1170-1176, Sep 2006. DOI: https://doi.org/10.1016/j.apmr.2006.05.020

[22] D. M. Perriman et al., "Validation of the flexible electrogoniometer for measuring thoracic kyphosis," Spine, Vol. 35, No. 14, pp. 633-640, Jun 2010. DOI: https://doi.org/10.1097/BRS.0b013e3181d13039

[23] J. Crosbie et al., "Effects of mastectomy on shoulder and spinal kinematics during bilateral upper-limb movement," Physical Therapy, Vol. 90, No. 5, pp. 679-692, May 2010. DOI: https://doi.org/10.2522/ptj.20090104

[24] W. G Yoo, C. H. Yi, and M. H. KIM, "Effects of a proximity-sensing feedback chair on head, shoulder, and trunk posture when working at a visual display terminal," Journal of Occupational Rehabilitation, Vol. 16, pp. 631-637, Nov 2006. DOI: https://doi.org/10.1007/s10926-006-9059-7

[25] K. P. Granta, E. Pogers, and K. Moorhouse, "Effects of static flexion–relaxation on paraspinal reflex behavior," Clinical Biomechanics, Vol. 20, No. 1, pp. 16-24, Jan 2005. DOI: https://doi.org/10.1016/j.clinbiomech.2004.09.001

[26] H. J. O'Gorman and G. A. Jull, "Thoracic kyphosis and mobility: the effect of age," Physiotherapy Practice, Vol. 3, No. 4, pp. 154-162, 1987. DOI: https://doi.org/10.3109/09593988709044180