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The Effects of Head Position in Different Sitting Postures on Muscle Activity with/without Forward Head and Rounded Shoulder

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Purpose: Differences in scapular kinematics and muscle activity appear in the forward head and rounded shoulder posture (FHRSP). Thus, the aim of this study was to investigate the following effects according to different postures on scapular kinematics and muscle activity around scapular region in individuals with and without FHRSP during overhead reaching task.

Methods: Thirty pain-free subjects with/without FHRSP participated in this study. All subjects were positioned into three positions: habitual head posture (HHP), self-perceived ideal head posture (SIHP) and therapist-perceived neutral head posture (TNHP). Muscle activities of upper trapezius (UT), lower trapezius (LT) and serratus anterior (SA) were measured during overhead reaching task.

Results: Muscle activity of trapezius muscle (UT and LT) during HHP was significantly higher than SIHP and TNHP in FHRSP group ($p<0.05$), but there was no difference between SIHP and TNHP. SA also significantly increased muscle activity in HHP more than SIHP and TNHP in FHRSP group ($p<0.05$), but there was no significant difference between SIHP and TNHP. In Non-FHRSP group, although there was a tendency of different muscle activities among three postures, it was not statistically significant.

Conclusion: This result demonstrates that muscle activity associated with overhead reaching task is increased in HHP which affects the scapular kinematics and SIHP contributes changed scapular kinematics and proper recruitment of muscle activity in FHRSP similarly to TNHP.

Key Words: Posture, Head, Shoulder, Electromyography, Muscles

I. Introduction

Poor posture such as forward head posture (FHP) and rounded shoulder posture is well-known as intrinsic risk factors of shoulder pain and dysfunction1. It has been reported that this poor posture altered scapular position, kinematics and muscle activity around shoulder region by making increased forward head, severe thoracic kyphosis and anterior shoulder position.[2,3] Especially, development of neck symptoms is highly associated with sustained non-neutral spinal postures, resulting in increased muscle activity of shoulder stabilizers such as upper trapezius, lower trapezius and serratus anterior muscle which are related to cervical spine.[1]

Proper head posture has been reported to be in a normal state of well-balanced musculoskeletal system, minimizing the stresses and strains provided to neck-shoulder region.[4] However, individuals with forward head posture showed the increased extensor torque around the upper cervical region and higher levels of vertebral loading.[5,6] This abnormal state causes musculoskeletal abnormality such as less scapular upward rotation, greater internal rotation as well as greater

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anterior tilting which may lead to difficulties to maintain an upright sitting posture[7-9]. In addition, it has been also reported that forward head posture also worsens diverse neuromuscular symptoms in upper body such as pain, numbness, functional loss by increasing muscle tension and stress on neck and shoulder region.[10-12]

Previous studies reported that different sitting postures make different shoulder kinematics and muscle activity. In O'Sullivan's study,[13] it is reported that three different sitting postures influenced spinal curvature and trunk muscle activities respectively and Mclean[14] suggests that upright sitting posture reduced muscle activation of upper trapezius. In addition, it is also reported that ideally neutral upright posture is difficult to be made without feedback. Kieran[15] mentioned that not only manual feedback but also verbal feedback were necessary to facilitate neutral sitting postures. That is, that study implied that it is difficult for individuals solely to facilitate neutral sitting postures without any feedback or instruction. However, there are also controversial opinions. Several previous studies reported that self-ideal neutral posture had also positive effects on improving altered shoulder kinematics and muscle activity. Edmondston[16] found subjectively perceived ideal posture showed similar results to corrected posture by therapists in other studies and Kwon[17] also reported significant differences in subjectively ideal head posture compared with habitual sitting posture. Furthermore, there is only limited evidence of influences of cervical posture to cervico-thoracic muscle activity.

Therefore, the aim of this study was to investigate the following effects according to different postures on scapular kinematics and muscle activity around scapular region by comparing three different head postures, habitual head posture (HHP), self-perceived ideal head posture (SIHP) and therapist-perceived neutral head posture (TNHP).

II. Methods

1. Subjects

Thirty pain-free subjects with/without the forward head and rounded shoulder posture (FHRSP) were recruited from university campus (Table 1). Subjects were excluded if they reported a history of neck and shoulder pain or any current pain, upper limb injury, displayed musculoskeletal pathology of cervical or thoracic, and neurological disorders limiting activities. The FHRSP was diagnosed by forward head angle (FHA) ≤54.0° and forward shoulder angle (FSA) ≤50.0° based on observational and photogrammetry methods according to previous studies to separate the FHRSP group and the Non-FHRSP group.[18-20] All subjects provided written informed consent prior to participation. Ethical approval was obtained from the local university research ethics committee.

Table 1. General characteristics of the subjects

	FHRSP group	Non-FHRSP group
Gender (M/F)	15(7/8)	15(8/7)
Age (years)	21.53 ± 1.64	21.20 ± 1.66
Height (cm)	166.00 ± 9.02	166.87 ± 9.49
Weight (kg)	61.47 ± 11.08	56.07 ± 10.12
*FHA (°)	50.05 ± 2.33	58.91 ± 2.56
*FSA (°)	46.51 ± 3.84	57.61 ± 5.17

*$p<0.05$; FHRSP=Forward head and rounded shoulder posture; FHA=Forward head angle; FSA=Forward shoulder angle

2. Experimental methods

1) FHRSP measurement

Postural data of the FHRSP were collected using a digital imaging technique to evaluate head, neck, and shoulder posture in the sitting position. A digital camera (EOS 1000D, Cannon, Japan) was placed at a tripod 1 m high and 3.5 m from the wall on a fixed base without rotation or tilt. All subjects were instructed to sit on the chair beside background wall to take capture of saggital plane of their upper body. Before capturing their saggital plane, they were asked to move head forward and backward in the full range of motion three times and then return to beginning position to make their natural head posture with looking straight ahead. The markers which were for the measurement of head/shoulder angle were placed on the tragus of ear, acromion and spinous process of C7. Adobe Photoshop (San Jose, CA, USA) was used in this study to measure FHA and FSA. FHA was determined from the vertical anteriorly to the line between the tragus of ear and C7 spinous process and FSA was also determined by measuring from the vertical posteriorly to a line between C7 spinous process and the acromion. This procedure was based on previous studies which of reliability and validity were well-established.

2) Electromyography (EMG) measurement

A four channel surface EMG system (MP30, Biopack, USA) was used to measure the muscle activity and EMG signals were recorded with pre-amplified electrodes (Biopack System, Biopack, USA) in this study. Three muscles such as upper trapezius (UT), lower trapezius (LT) and serratus anterior (SA) were selected as the target muscles to obtain EMG signals. The location point of EMG electrodes were as followings: (1) UT was lateral to the half-way point of an imaginary line formed by the posterior aspect of the acromion and the spinous process of C7,[21] (2) LT was next to the medial edge of the scapula at an obligue angle of 55°,[22] (3) SA was just below the axillary area, at the level of the inferior tip of the scapular, and just medial to the latissimus dorsi.[23] A ground electrode was placed on the right clavicle. Before attaching the electrodes, the skin over the electrode location was shaved, if needed, and cleaned with alcohol. All EMG recordings were conducted during overhead reaching task. EMG signal data were converted to digital signals using Acqknowlege software (Biopac System, Biopack, USA) for statistical analysis. EMG data were sampled at 1000 Hz and bandpass was filtered between 10 and 500 Hz.

3) Experimental procedure for assessments

This is a single session, repeated measures study. All subjects were in three sitting positions: habitual head posture (HHP), self-perceived ideal head posture (SIHP), and therapist-perceived neutral head posture (TNHP). In HHP, subjects were asked to sit on the chair comfortably with verbal instruction like 'sit as you usually do' with looking at the fixed point straight ahead. And then, they were instructed to sit in a self-balanced position which they thought is the ideal posture without any manual or verbal feedback on the posture. Finally, experienced therapists facilitated the neutral posture of subjects with manual and verbal instruction to reflect clinical practice. Each posture was held for 10 seconds, repeated three times with a 10-second relaxation between each trial. Each measurement was conducted three times in three different days to avoid the learning effects and muscle fatigue. The average value of angles and muscle activities was used for statistical analysis. All tests were performed by skilled physical therapists and the therapists were blinded. After setup was completed, muscle activity was measure d during overhead reaching task for three repetitions, three sessions During overhead reaching task, subjects were asked to raise their right arm from a position of arms relaxed at their side up to 180 degree at a self-selected speed with their elbow straight and non-elevated shoulder and a weight equal to 3% of body weight is needed to be lifted in that task. Subjects were provided with 30-second break to avoid muscle

Table 2. Changes of the muscle activity values (%MVIC) during the overhead reaching task among the head/shoulder postures

Muscle	Group	Head/shoulder posture			Posture	Group	Interaction (Posture x Group)
		HHP	SIHP	TNHP			
UT	FHRSP	38.52 ± 11.06	30.95 ± 8.55	30.49 ± 8.81	0.006*	0.008*	0.253
	Non-FHRSP	26.59 ± 12.65	25.72 ± 10.63	21.19 ± 11.07			
LT	FHRSP	23.44 ± 8.26	19.61 ± 7.16	18.62 ± 4.40	0.001*	0.069	0.070
	Non-FHRSP	15.78 ± 9.01	14.88 ± 10.50	13.92 ± 9.34			
SA	FHRSP	60.28 ± 15.54	47.64 ± 11.68	45.90 ± 18.12	0.002*	0.108	0.013*
	Non-FHRSP	43.88 ± 15.85	43.64 ± 16.15	41.78 ± 13.98			

*p<0.05; %MVIC=%Maximal voluntary isometric contraction; UT=Upper trapezius;
LT=Lower trapezius; SA=Serratus anterior; FHRSP=Forward head and rounded shoulder posture;
HHP=Habitual head/shoulder posture; SIHP=Self-perceived ideal head/shoulder posture;
TNHP=Therapist-perceived neutral head/shoulder posture

fatigue. The root mean square (RMS) values were calculated and the maximal EMG signals were obtained to normalize the EMG values during 5-sencond maximal voluntary isometric contractions (MVIC). The values of the first and last one second were discarded and the mean RMS of middle 3 seconds was calculated during humeral elevation. The %MVIC was measured three times and 60-second breaks were provided between each MVIC trial, and then the mean %MVIC during ascending motions was calculated for statistical analysis.

3. Statistical analysis

Demographic data, such as gender, age, height, and weight were analyzed by an independent t-test. In order to separate two groups, FHA and FSA, independent t-test was used again. The effect of the head/shoulder posture between two groups was determined using a 3 (head/shoulder postures: HHP, SIHP and TNHP) x 2 (groups: FHRSP, Non-FHRSP) ANOVA with repeated measures on three dependent variables (muscle activities of UT, LT, and SA). All statistical analyses were performed using PASW 18.0 for Windows. Statistical significance was set at $p<0.05$.

III. Results

Table 1 displays general characteristics of each group. There were no significant differences between the FHRSP group and the Non-FHRSP group in terms of gender, age, height, and weight ($p>0.05$). However, there was statistically significant difference of the FHA and the FSA between two groups, the Non-FHRSP group showing greater angle than the FHRSP group ($p<0.05$).

In the UT muscle activity, the results of the univariate analysis showed a lager main effect of the head/shoulder posture ($p<0.05$) and group ($p<0.05$), but there was no main effect of the posture-by-group interaction ($p>0.05$)(Table 2). In the LT muscle activity, the results showed a lager main effect in the head/shoulder posture ($p<0.05$), but not in the group ($p>0.05$) and the posture-by-group interaction

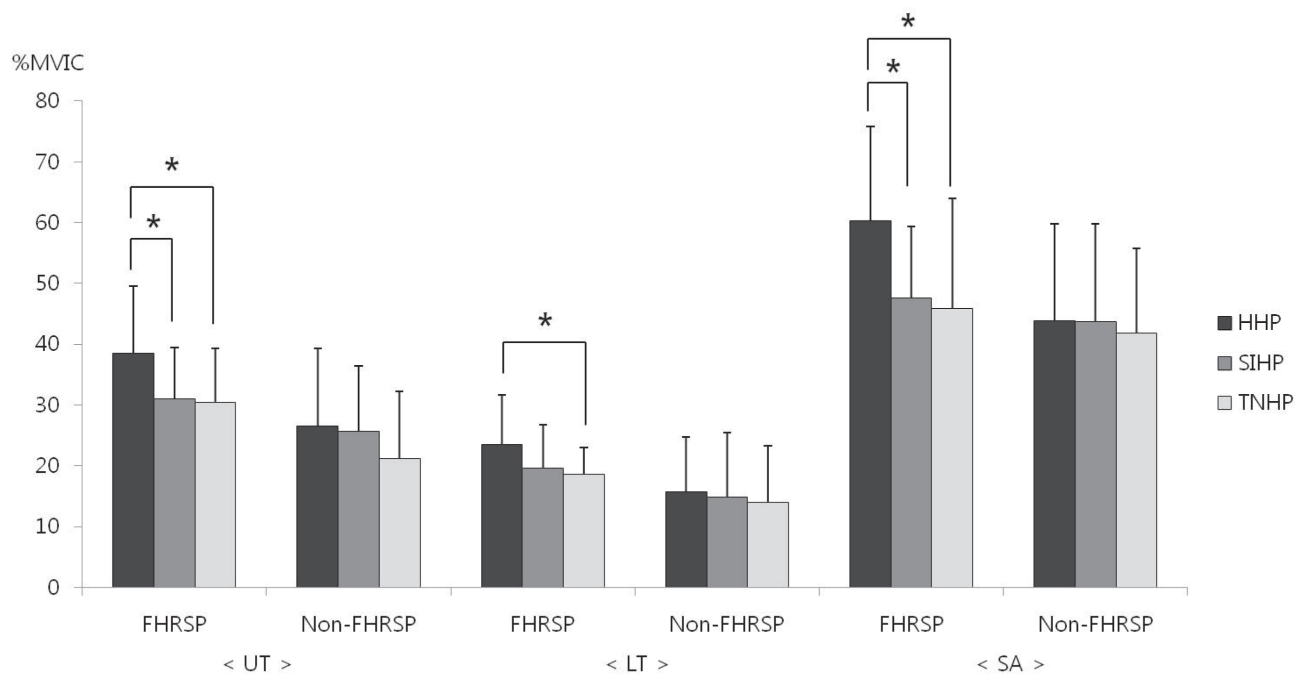

Figure1. Comparison of the mean of muscle activity (%MVIC) in 3 muscle groups across 3 head/shoulder postures: HHP, SIHP and TNHP between the FHRSP and the Non-FHRSP groups.
*p<0.05; %MVIC=%Maximal voluntary isometric contraction; UT=Upper trapezius;
LT=Lower trapezius; SA=Serratus anterior; FHRSP=Forward head and rounded shoulder posture;
HHP=Habitual head/shoulder posture; SIHP=Self-perceived ideal head/shoulder posture;
TNHP=Therapist-perceived neutral head/shoulder posture

($p>0.05$)(Table 2). In the SA muscle activity, the results also showed a lager main effect according to the head/shoulder posture ($p<0.05$) as well as the posture-by-group interaction ($p<0.05$), but group ($p>0.05$) showed no main effect (Table 2). That is, the main effect of posture-by-group interaction was shown only in SA, suggesting that the muscle activity of SA was significantly different according to head/shoulder posture between groups compared to other muscles.

IV. Discussion

Current study is to investigate if HHP has an effect on scapular kinematic and muscle activity around shoulder such as UT, LT and SA by comparing with SIHP and TNHP during overhead reaching task. Subjects were divided into two groups, FHRSP group and Non-FHRSP group according to FHA and FSA. All subjects were instructed to pose three head/shoulder postures: HHP, SIHP, and TNHP. Muscle activities of UT, LT and SA were measured during overhead reaching task to assess the difference of muscle activity among three postures. As a result, muscle activities of three muscles were significantly different from each posture. Muscle activities of UT, LT, and SA in HHP were more increased than SIHP and TNHP in the FHRSP group but there was no difference between SIHP and TNHP. In addition, there was no difference of muscle activities among three postures in Non-FHRSP. These results may imply that muscle activity associated with overhead reaching task is increased in HHP which affects the scapular kinematics and SIHP contributes changed scapular kinematics and proper recruitment of muscle activity similarly to TNHP.

Head/Shoulder angle, such as FHA and FSA were measured using photogrammetry to diagnose FHRSP. In recent studies, it is reported that measurement of angles between anatomical references is well-known to be effective on evaluating the changes of the head/shoulder posture.[24,25] In addition, visual observation of head position related to the anatomical references is commonly used and defined by Kendall's study.[26,27] In this study, Photogrammetry which is a simple and objective measurement tool for this visual observation of head position by analyzing the posture of different parts of body was used.[24,28] By using this photogrammetry, FHA and FAS can be clinically measured as reliable and valid method to diagnose the FHRSP as mentioned in previous studies.[20]

Altered kinematics and muscle activity were assessed in three head posture and UT, LT and SA muscles were chosen because it is reported that those muscles have a key role in scapular movement which is easily diminished by the FHRSP.[29,30,31] In addition, Bostard demonstrated FHRSP increases thoracic kyphosis and altered scapular position, kinematics, and muscle activity.[2] Thus, individuals with FHRSP are believed to have altered muscle activities of UT, LT and SA comparing with individuals without FHRSP. That's why those muscles were selected to assess the changes of muscle activity.

Muscle activity of trapezius muscle (UT and LT) during HHP was higher than SIHP and TNHP in FHRSP group, but there was no difference between SIHP and TNHP. In Non-FHRSP group, although there was a tendency of different muscle activities among three postures, it was not statistically significant. Muscle activity of trapezius muscle is believed to increase in FHRSP. It is reported that FHRSP causes the shortened length and increased tension of levator scapula.[7] Since levator scapula is the antagonist muscle and trapezius muscle is agonist muscle for scapular upward rotation, once the tension of levator scapula is increased by FHRSP, the upward rotation of scapula is prohibited.[7] In order to compensate this abnormal mechanism, it is believed that trapezius muscle is needed to be more activated to a greater extension. In addition, trapezius muscle make a coupling force with serratus anterior, resulting in the alteration of scapular movement such as excessive upward rotation and anterior tilting.[8]

The SA muscle showed increased muscle activity in HHP more than SIHP and TNHP in FHRSP group, but there was no significant difference between SIHP and TNHP. In Non-FHRSP group, although there was a tendency of different muscle activities among three postures, it was not statistically significant. Previous studies reported that FHRSP changes the greater internal rotation and anterior tilting angle of scapula.[3] The SA muscle is reported to control the anterior/posterior tilting and upward/downward rotation of the scapular.[32] Once

FHRSP alters the scapular kinematics, SA activation becomes changed to control the altered kinematics. In addition, it is also reported in previous study that FHRSP increases thoracic kyphosis resulting in decreased scapular upward rotation.[2,3] Individuals with FHRSP shows the increased scapular anterior tipping by 3~4° resulting in increased thoracic kyphosis and short pectoralis minor length.[2,3] Thus it is believed that SA muscle activity is needed to increase in order to compensate the abnormal scapular movement because SA is the main muscle to play a key role of scapular upward rotation.

In conclusion, the findings of this study indicated that different head postures have different effects on head/shoulder kinematics and muscle activity. This may support for the clinical approach that postural alterations related to FHRSP can change the scapular kinematics and muscle activity in individuals with FHRSP. There are some limitations in this study. First, we didn't investigate other muscles which can affect the head/shoulder kinematics. Second, characteristics of personal habitual posture were not assessed in this study, because the aim of this study was just to find the following effects according to different postures. Prospective studies should consider the diverse muscles and possibility of personal habitual posture related to various movements of scapular and shoulder.

References

1. Szeto GP, Straker LM, O'Sullivan PB. Emg median frequency changes in the neck–shoulder stabilizers of symptomatic office workers when challenged by different physical stressors. J Electromyogr Kinesiol. 2005;15(6):544–55.
2. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. J Orthop Sports Phys Ther. 2005;35(4):227–38.
3. Finley MA, Lee RY. Effect of sitting posture on 3–dimensional scapular kinematics measured by skin–mounted electromagnetic tracking sensors. Arch Phys Med Rehabil. 2003;84(4):563–8.
4. Caneiro JP, O'Sullivan P, Burnett A et al. The influence of different sitting postures on head/neck posture and muscle activity. Man Ther. 2010;15(1):54–60.
5. Silva AG, Johnson MI. Does forward head posture affect postural control in human healthy volunteers? Gait Posture. 2013;38(2)352–3.
6. Kang JH, Park RY, Lee SJ et al. The effect of the forward head posture on postural balance in long time computer based worker. Ann Rehabil Med. 2012;36(1):98–104.
7. Weon JH, Oh JS, Cynn HS et al. Influence of forward head posture on scapular upward rotators during isometric shoulder flexion. J Bodyw Mov Ther. 2010;14(4):367–74.
8. Thigpen CA, Padua DA, Michener LA et al. Head and shoulder posture affect scapular mechanics and muscle activity in overhead tasks. J Electromyogr Kinesiol. 2010;20(4):701–9.
9. Falla D, Jull G, Russell T et al. Effect of neck exercise on sitting posture in patients with chronic neck pain. Phys Ther. 2007;87(4):408–17.
10. Chae YW. The effect of forward head posture and cervical rom on chronic and episodic tension–type headache in university students. J Korean Soc Phys Ther. 2009;21(2):71–7.
11. Bae YH, Lee GC. Effect of motor control training with strengthening exercises on pain and muscle strength of patients with shoulder impingement syndrome. J Korean Soc Phys Ther. 2011;23(6):1–7
12. Weon JH, Jung DY. Comparison of the muscle activities of upper trapezius and middle deltoid between subjects with and without elevation of shoulder girdle during arm elevation. J Korean Soc Phys Ther 2012;24(6):388–92.
13. O'Sullivan PB, Dankaerts W, Burnett AF et al. Effect of different upright sitting postures on spinal–pelvic curvature and trunk muscle activation in a pain–free population. Spine (Phila Pa 1976). 2006;31(19):707–12.
14. McLean L. The effect of postural correction on muscle activation amplitudes recorded from the cervicobrachial region. J Electromyogr Kinesiol. 2005;15(6):527–35.
15. O'Sullivan K, O'Dea P, Dankaerts W et al. Neutral lumbar spine sitting posture in pain–free subjects. Man Ther. 2010;15(6):557–61.
16. Edmondston SJ, Chan HY, Ngai GC et al. Postural neck pain: An investigation of habitual sitting posture, perception of 'good' posture and cervicothoracic kinaesthesia. Man Ther. 2007;12(4):363–71.
17. Kwon JW, Nam SH, Choi YW et al. The effect of different head position in sitting on head/shoulder posture and muscle activity. J Korean Soc Phys Ther. 2013;25(4):217–23
18. Raine S, Twomey LT. Head and shoulder posture variations in 160 asymptomatic women and men. Arch Phys Med Rehabil. 1997;78(11):1215–23.
19. Harrison AL, Barry–Greb T, Wojtowicz G. Clinical measurement of head and shoulder posture variables. J Orthop Sports Phys Ther. 1996;23(6):353–61.
20. Salahzadeh Z, Maroufi N, Ahmadi A et al. Assessment of forward head posture in females: Observational and

photogrammetry methods. J Back Musculoskelet Rehabil. 2014;27(2):131–9.
21. Netto KJ, Burnett AF. Reliability of normalisation methods for emg analysis of neck muscles. Work. 2006;26(2):123–30.
22. Hermens HJ, Freriks B, Disselhorst-Klug C et al. Development of recommendations for semg sensors and sensor placement procedures. J Electromyogr Kinesiol. 2000;10(5):361–74.
23. Solomonow M, Baratta RV, Banks A et al. Flexion-relaxation response to static lumbar flexion in males and females. Clin Biomech (Bristol, Avon). 2003;18(4):273–9.
24. Grimmer-Somers K, Milanese S, Louw Q. Measurement of cervical posture in the sagittal plane. J Manipulative Physiol Ther. 2008;31(7):509–17.
25. Yip CH, Chiu TT, Poon AT. The relationship between head posture and severity and disability of patients with neck pain. Man Ther. 2008;13(2):148–54.
26. Garrett TR, Youdas JW, Madson TJ. Reliability of measuring forward head posture in a clinical setting. J Orthop Sports Phys Ther. 1993;17(3):155–60.
27. Hanten WP, Lucio RM, Russell JL et al. Assessment of total head excursion and resting head posture. Arch Phys Med Rehabil. 1991;72(11):877–80.
28. van Niekerk SM, Louw Q, Vaughan C et al. Photographic measurement of upper-body sitting posture of high school students: A reliability and validity study. BMC Musculoskelet Disord. 2008;9(1):113.
29. Szeto GP, Straker L, Raine S. A field comparison of neck and shoulder postures in symptomatic and asymptomatic office workers. Appl Ergon. 2002;33(1):75–84.
30. Ludewig PM, Cook TM. The effect of head position on scapular orientation and muscle activity during shoulder elevation. J Occup Rehabil. 1996;6(3):147–58.
31. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther. 2000;80(3):276–91.
32. Ludewig PM, Cook TM, Nawoczenski DA. Three-dimensional scapular orientation and muscle activity at selected positions of humeral elevation. J Orthop Sports Phys Ther. 1996;24(2):57–65.