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Original Article

Changes in upper-extremity muscle activities due to head position in subjects with a forward head posture and rounded shoulders

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Abstract. [Purpose] This study investigated upper-extremity muscle activities in natural, ideal, and corrected head positions. [Subjects and Methods] Forty subjects with a forward head posture and rounded shoulder were recruited and randomly assigned to the natural head position group (n = 13), ideal head position group (n = 14), or corrected head position group (n = 13). Muscle activities were measured using a four-channel surface electromyography system at the sternocleidomastoideus, upper and lower trapezius, and serratus anterior muscles on the right side during an overhead reaching task. [Results] The muscle activities of the upper trapezius and serratus anterior differed significantly among head positions. Post hoc tests revealed significant differences between natural and ideal head positions, and natural and ideal head positions for both the upper trapezius and serratus anterior. [Conclusion] Recovery of normal upper trapezius and serratus anterior muscle functions plays an important role in correcting forward head posture and rounded shoulders.

Key words: Forward head posture, Muscle activity, Round shoulder

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INTRODUCTION

People sit with their head positioned in various ways; this is determined by a combination of factors including musculoskeletal structure, age-related body changes, motor performance, occupation, and cultural customs[1–4)]. A forward head posture with rounded shoulders (FHPRS) due to a poor sitting posture is defined as a forward head position with thoracic kyphosis and more anterior shoulder positions; such a posture is associated with altered scapular positions, kinematics, and muscle activities[5–7)]. These alterations consequently increase muscle tension and stress at the neck and shoulder, resulting in pain, numbness, loss of function, and various neuromuscular symptoms, which most often affect the upper body[8–10)].

While sitting, forward head inclination involves a combination of lower cervical flexion, upper cervical extension, and rounded shoulders, which reduce the average lengths of muscle fibers, contributing to extensor torque around the upper cervical joint. In addition, this abnormal state causes musculoskeletal abnormalities such as decreased scapular upward rotation as well as greater internal rotation and anterior tilting, which may lead to difficulties maintaining an upright sitting posture[8, 9, 11, 12)].

Many previous studies report that proper head position is a state of musculoskeletal balance that involves minimizing the stresses and strains acting on the upper body[3, 13, 14)]. Frequent correction to an upright neutral postural position serves two functions. First, it may provide regular reductions of adverse loads on the cervical joints induced by poor spinal, cervical, and scapular postures. Second, it may train the deep postural-stabilizing muscles of the spine to better perform their functional postural-supporting role. Hence, assuming a proper head position is a common approach for the treatment of neck and shoulder pain syndromes. In addition, different sitting postures lead to different shoulder kinematics and muscle activities. In particular, an upright sitting posture reduces activation of the upper trapezius. Previous studies indicate a neutral upright posture is difficult to achieve without manual or verbal feedback[3, 15)]. However, this remains controversial, as several authors report subjectively perceived ideal postures produce results similar to postures corrected by therapists, positively affecting shoulder kinematics and muscle activities[16, 17)]. Therefore, the present study examined whether different head positions influence upper-extremity muscle activities in people with an FHPRS.

SUBJECTS AND METHODS

Forty subjects with an FHPRS were recruited. The subjects had no history of neck or shoulder pain, or current

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pain, upper-limb injury, cervical or thoracic musculoskeletal pathology, or neurological disorder limiting activities. An FHPRS was defined as a forward head angle (FHA) ≤54.0° and a forward shoulder angle (FSA) ≤50.0° measured on the basis of previously described observational and photogrammetry methods[11, 18, 19]. All subjects provided written informed consent prior to participation. This study was conducted in accordance with the ethical standards of the Declaration of Helsinki. Ethical approval was obtained from the local university research ethics committee.

Subjects were asked to adopt three head positions while sitting postures: a natural head position (NHP), ideal head position (IHP), and corrected head position (CHP). For the NHP, subjects were instructed to sit in a comfortable relaxed position using a verbal instruction similar to "sit as you usually do" while looking at a fixed point directly ahead. For the IHP, subjects were instructed to sit with the head in a "balanced position" considered by the subjects to be ideal without any manual or verbal feedback regarding the position adopted. For the CHP, the subjects were placed in a neutral posture by experienced therapists using manual and verbal feedback to reflect clinical practice. Each posture was held for 10 seconds and repeated 3 times, and a 10-second rest period was allowed between repetitions.

Head and shoulder postures were assessed using a digital imaging technique arranged to capture the sagittal plane of the upper body in a sitting position. A digital camera (EOS 1000D, Cannon, Japan) was placed on a tripod 1 m high and 3.5 m from the wall on a fixed level base. Before capturing sagittal images, subjects were asked to move their heads forward and backward through the full range of motion three times and then return to the starting position looking directly ahead. Reflective markers were placed on the tragus of the right ear, acromion, and C7 spinous process. Adobe Photoshop version 7.0 (San Jose, CA, USA) was used to determine FHAs and FSAs from lateral view in photographs. The FHA was determined from the vertical anterior to the line between the tragus of ear and C7 spinous process. The FSA was determined by measuring from the vertical posterior to a line between the C7 spinous process and acromion. These measures have been used in previous studies, and their intra- and inter-rater reliabilities are well established[19–21].

Muscle activity was measured using a four-channel surface electromyography (EMG) system (MP30, Biopac, Goleta, CA, USA). EMG signals were recorded using a pre-amplified electrode (Biopac System, Biopac, USA). In each head position, muscle activity was measured during an overhead reaching task in 3 sessions comprising 3 repetitions with a 30-second rest periods between repetitions. All subjects were instructed to raise their right arm from a relaxed side position up to 180° at a self-selected speed, with the elbows straight and shoulders non-elevated while holding a weight equal to 3% of body weight. The muscle activities of the sternocleidomastoideus (SCM), upper and lower trapezius (UT and LT, respectively), and serratus anterior (SA) were measured on the right side during the overhead reaching task. The EMG electrode locations were as follows: (1) SCM, lower third of the line connecting the sternal notch and mastoid process[1]; (2) UT, lateral to the midpoint of an imaginary line formed by the posterior aspect of the acromion and the spinous process of C7[22]; (3) LT, next to the medial edge of the scapula at an oblique angle of 55°[23]; (4) SA, on the midaxillary line of the right fifth rib[24]. A ground electrode was placed on the right clavicle. For statistical analysis, EMG signal data were sampled at 1,000 Hz, bandpass filtered between 10 and 500 Hz, and converted to digital signals using Acknowledge software (Biopac System, Biopac, USA). The root mean square values of EMG data were calculated, and maximum EMG signals, which were used for normalization purposes, were acquired during maximum voluntary isometric contractions (MVIC) for 5 seconds. The values obtained during the first and last second were discarded, and average root mean square values of the remaining 3 seconds were calculated. %MVIC was measured three times with a 60-second rest period between each MVIC trial. The mean %MVIC values were subsequently calculated and analyzed.

Table 1. FHA, FSA, and muscle activities with respect to postural training

Parameters	NHP	IHP	CHP
FHA (°) $^{a, b}$	49.2 ± 2.8	54.5 ± 3.1	59.6 ± 3.1
FSA (°) $^{a, b}$	49.2 ± 5.2	56.4 ± 7.3	60.6 ± 7.1
SCM	4.1 ± 2.5	4.5 ± 2.9	5.6 ± 3.7
UT $^{a, b}$	39.8 ± 10.1	33.1 ± 9.6	27.7 ± 6.2
LT	25.6 ± 22.5	20.1 ± 15.0	18.3 ± 11.7
SA $^{a, b}$	59.6 ± 19.4	45.3 ± 14.8	39.4 ± 15.7

Data are mean ± SD. NHP: natural head position, IHP: ideal head position, CHP: corrected head position, FSA: forward head angle, FSA: forward shoulder angle, SCM: sternocleidomastoideus, UT: upper trapezius, LT: lower trapezius, SA: serratus anterior, ^{a} significantly difference between NHP and IHP; ^{b} significantly different between NHP and CHP, $p < 0.05$

Statistical analysis was conducted using SPSS version 18.0 for Windows. All results are presented as mean ± standard deviation. Demographic data including age, height, and weight were analyzed by one-way ANOVA. Postural angles (i.e., FHA and FSA) and muscle activities (i.e., SCM, UT, LT, and SA) in different head positions (i.e., NHP, IHP, and CHP) were analyzed by one-way ANOVA and the Tukey LSD post hoc test. The level of significance was set at $p < 0.05$.

RESULTS

There were no significant differences among three head position groups with respect to sex, age, height, or weight ($p > 0.05$). The FHA and FSA differed significantly among the NHP, IHP, and CHP groups. The post hoc test showed significant differences between the NHP and IHP, and NHP and CHP with respect to the FSA ($p < 0.05$, Table 1).

Regarding muscle activities, the UT and SA muscle activities differed significantly among groups ($p < 0.05$, Table 1). However, there were no differences in SCM or LT muscle activity among groups ($p > 0.05$). The post hoc test showed there were significant differences between the NHP and IHP, and NHP and CHP groups with respect to both UT and SA muscle activity ($p < 0.05$, Table 1); however, there were no significant differences between the IHP and CHP groups ($p > 0.05$).

DISCUSSION

In the current study, the FHA and FSA were significantly greater in the IHP and CHP groups than the NHP group. Moreover, the IHP increased the FHA and FSA to almost the same extent as the CHP, which was corrected by a therapist. Meanwhile, the muscle activities of the UT and SA were lower in the IHP and CHP group than the NHP group. These results suggest the effects of the IHP are similar to those of the CHP.

The present findings demonstrate the IHP and CHP improved shoulder kinetics and movement patterns Thus, these finding indicate the IHP improves shoulder kinetics and muscle activities in individuals with an FHPRS during an overhead reaching task. Scapular anterior tilting and internal rotation have been reported in individuals with an FHPRS in comparison to individuals with an ideal posture[14, 16, 25)]. Moreover, the NHP is reported to be associated with increased thoracic flexion and head/neck flexion with a greater anterior translation of the head, when compared to neutral head-neck alignment with shoulder blades slightly retracted[3)]. The differences between postures with respect to the FHA and FSA are likely due to muscular imbalances around the shoulder girdle, because we measured UT and SA muscle activities.

Several studies report that SA, UT, and LT activities are important factors in an FHPRS[26, 27)]. In addition, the SA contributes to and controls many scapular movements such as anterior/posterior tilting and upward/downward rotation[7, 14, 27)]. When an FHPRS alters scapular kinematics, SA activation is consequently changed. In addition, an FHPRS is reported to lead to thoracic kyphosis, resulting in decreased scapular upward rotation[30)]. Therefore, SA muscle activity must increase to compensate for abnormal scapular movement, i.e., the SA muscle must overcome the resistance generated by passive tension around the scapulae in abnormal postures such as an FHPRS.

Trapezius muscle activity is thought to be elevated in an FHPRS[3, 28, 29)]. An FHPRS is reported to shorten and increase the tension of the levator scapula[30)]. As the levator scapula and trapezius are the antagonist and agonist muscles for scapular upward rotation, respectively, upward rotation of the scapula is prohibited if the tension of the levator scapula is increased by an FHPRS. In order to compensate for this abnormal mechanism, the trapezius muscle should be more activated for greater extension[12)]. In addition, the trapezius generates a coupling force with the serratus anterior, resulting in altered movements such as excessive upward rotation and anterior tilting.

In conclusion, the findings of this study indicate different head positions have different effects on head/shoulder kinematics and muscle activities. The results corroborate the clinical notion that postural alterations related to an FHPRS can change scapular kinematics and muscle activities in individuals with such a posture[6, 10, 31)]. Therefore, recovery of normal functions of the UT and SA plays an important role in correcting an FHPRS. However, we did not divide upper- and lower-cervical spine kinetics into deep and superficial cervical categories. Furthermore, the suboccipital muscles were not assessed. Therefore, further studies should be conducted to determine the roles of other muscles and relationships between habitual posture and movements of the scapulae and shoulders.

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