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The Evaluation of Trunk Muscle Endurance in People with And Without forward Head Posture: a Cross-Sectional Study

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SUMMARY

Background. Muscle endurance is an important factor to maintain the proper posture. Improper posture in head and neck may alter muscle endurance in other segments of the vertebral column. This cross-sectional study was first aimed to compare the trunk muscle endurance in two groups of people with and without forward head posture. The second aim was to explore the relationships between forward head posture and trunk muscles endurance.

Methods. Ninety seven participants (70 males and 27 females; mean age = 23.30 yrs.; mean body mass index = 22.76 Kg/m^2) were assigned to two groups of people with forward head posture and people without forward head posture based on the amount of craniovertebral angle measured by photogrammetry technique. The endurance of trunk flexor, extensor and side-flexor muscles was measured in seconds and compared between groups.

Results. The endurance of trunk muscles was significantly lower in the forward head posture group compared to control group ($P < 0.05$). There were also negative relationships between the severity of forward head posture and the endurance of trunk muscles ($P < 0.05$).

Conclusions. The low endurance of trunk muscles in the presence of forward head posture may lead to poor muscular control of the spine and may predispose people to pain and disability in the future not only in the neck but also in the other spinal segments.

KEY WORDS

Head; neck; torso; muscle; posture; photogrammetry; physical endurance.

BACKGROUND

Forward head posture (FHP) is one of the more common habitual and/or structural poor postures resulted from various postural or occupational demands such as excessive computer and smartphone usage (1, 2). FHP causes numerous complaints such as neck pain and disability (1-4). It is worth noting that FHP not only affects the function of the head and neck musculoskeletal structures, but also affects the whole body postural control (5). Previous studies revealed that the head position has effects on the lower spine posture and the activity of the trunk muscles during lifting and prone bridging tasks (6, 7). Hlavenka (6), *et al* compared the effects of retracting neck posture with free style neck posture on the activation of the neck and trunk muscles and also trunk posture in people performing moderate intensity lifting task. The retracted neck position led to less flexion in the lumbar spine. This position also altered the activation of the neck, thoracic, lumbar and abdominal muscles (6). Yu (7), *et al.* also examined the effects of three head positions (head in neutral, in flexion, and in extension) on abdominal and lumbar muscle activities during prone bridging exercise. The activity of the rectus femoris and multifidus muscles was varied in head flexion and extension postures compared to the neutral head posture (7). These findings revealed that head posture may have effects on the trunk and lumbar vertebral alignment and consequently alters the muscular performance not only in the cervical spine but also in other spinal levels (6, 7). On the other hand, the thoracic and lumbar posture can alter the head/neck position and the activity of cervical and thoracic muscles (8). In this regard, the amount of head translation is higher in the slump sitting position compared to the lumbo-pelvic and thoracic upright sitting postures (8). Cervical erector spine muscle activity is also related to the type of the acquired sitting posture (8). Furthermore, the ability of trunk muscles to maintain enough activity level over a long period of time is necessary to maintain the neutral spine posture (9, 10). It seems that inadequate muscle endurance may lead to postural mal-alignments, especially in the young population (4, 11, 2). This may predispose people to pain and disability in the future (7).

As mentioned earlier, FHP is a common poor posture in people suffering neck pain (4) and interestingly a national survey in the US disclosed that low back pain and neck pain is the most common disabling complaints among adults which often occur concurrently (13). Therefore, the importance of assessing trunk muscle endurance in the presence of the habitual head postures such as FHP is highlighted. Furthermore, muscle endurance tests of lower trunk can be used to predict low back pain (14). Based on the authors' knowledge, the endurance of trunk muscles in people with FHP is not clarified yet. Evaluating the endurance of trunk muscles in people with FHP may have implications in designing preventive strategies in the clinical settings. Therefore, the first hypothesis was that the trunk muscle endurance of people with FHP was different from people without FHP. The second hypothesis was that the FHP severity could be related to the amount trunk muscle endurance. Accordingly, the present study was conducted to evaluate the trunk muscle endurance in peoples with and without FHP and to determine the relationships between FHP severity and trunk muscle endurance.

MATERIALS AND METHODS

Participants

Ninety seven recreationally active participants (70 males and 27 females) aged 23.30 ± 2.24 years (mean ± SD), and with body mass index (BMI) ranged 22.76 ± 2.63 kg/m^2 volunteered to participate in this cross-sectional study using convenient sampling. The amount of power was calculated by G Power software version 3.1.9.2 and was equal to 0.88. The inclusion criteria were having no complaints of neck and/or back pain during the last 6 months leading treatments (15, 16). The exclusion criteria were as follows: subjects with the neurological deficits, history of trunk or neck surgery, doing professional sport, the presence of obvious spinal deformities, or obvious medical conditions that contraindicated vigorous exercise (15, 16). Written informed consent was obtained from participants and the study protocol was approved by the local ethics committee (Ethic's code: …1395.555). Also, written informed consent was obtained from the participant who volunteered in preparing illustrations of this study. The study meets the ethical standards of the journal (17). This study was conducted in the posture research laboratory of Tabriz University of Medical Sciences since 2016 until 2018.

Experimental procedure

Initially in a pilot study, the intra-rater reliability of the trunk muscle endurance tests was evaluated in 30 participants with FHP revealing ICC values were ranged 0.93-0.98 for photogrammetry method and endurance testing. Two qualified physiotherapist with 15 years' experience in manual therapy field were performed examinations. One experienced physiotherapist evaluated FHP through measuring craniovertebral angle (CVA) in the standing position using photogrammetry technique. People with CVA values of lower than 48° were considered to have FHP (18). Another qualified physiotherapist assessed the endurance of trunk flexor, extensor, and lateral flexor muscles. The endurance tests were applied in a random order. The endurance scores were measured in seconds and the tests were terminated if the subject cannot maintain the tests' defined position based on special considerations for each test or experiences discomfort or pain (19). The rest period between each trial was 5 minutes (3 trials for all tests) and the rest interval between separated was 10 minutes. Detailed explanations of the procedures were given to all participants. Verbal and tactile feedbacks were also provided to the subjects to maintain the endurance test positions accurately (20). The endurance examiner was not aware of the results of photogrammetry to minimize the risk of bias. Prior to the data collection, the examiners practiced test procedures to ensure accurate protocols were applied.

Measurement of craniovertebral angle (CVA)

Photogrammetry technique was used to measure the CVA with a digital camera (Fuji Film JX700, Japan) which was placed laterally at the shoulder height about 1.5 meters from the subjects in a standing position on a fixed base without tilt and rotation. The CVA demonstrates the angle between the spinous process of the seventh neck vertebrae (C7) and the ear tragus with the horizontal line through neck seventh vertebrae. Self-balanced positioning was instructed to the participants to standardize head and neck posture based on the previous recommendations (16, 21). The importance of maintaining the neutral head posture was explained to participants. CVA was calculated using AutoCAD software (**figure 1**).

Endurance tests

Biering-Sorenson test

Biering-Sorenson test is the most widely used procedure to evaluate the isometric endurance of trunk extensor muscles (20). The subject was asked to lie prone with the lower body fixed to the table in all joints by three straps. Upper body was out of the table and extended over a stool. The participant was asked to release the table while upper extremities were held in the crossed position on the chest. It was instructed to lift off the upper body from the floor and maintain the position horizontally as long as possible (8). As long as the position was maintained the examiner calculated the endurance time (**figure 2**).

Trunk flexor endurance test

The participant was sat on a table against a wedge with an angle of 60° from the table. Hips and knees were held at 90° flexed position and feet were fixed to the table. The arms were folded across the chest and toes were held fixed by another examiner. The subject was asked to maintain the body position while the supporting wedge was pulled back about 10 cm to start the test (19). The examiner calculated the endurance time in seconds. The test continued as long as the subject maintain the position (**figure 3**).

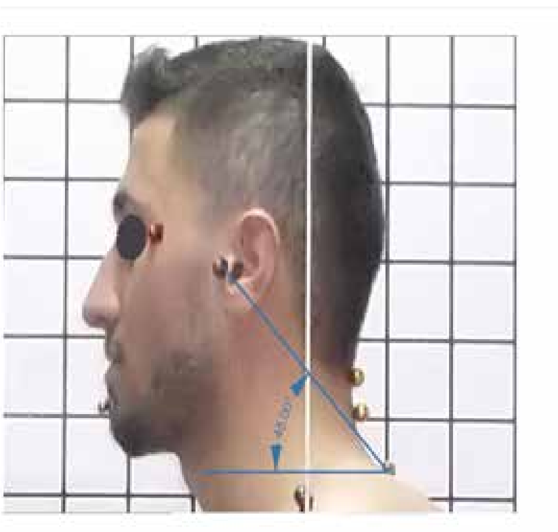

Figure 1. Measurement of the craniovertebral angle. One landmark was placed on the tragus of the ear and the other landmark was placed on the spinous process of the seventh cervical vertebrae.

Side bridge test

The subject was requested to lie on an exercise mat on one side with legs positioned at the extension. The upper leg was placed in front of the lower leg on the mat. The participant was instructed to lift off his hips and maintain the full body in straight line with support on the elbow and feet. The upper arm was maintained on the opposite shoulder. The test terminated if the hips returned to the table (19). The examiner calculated the time as long as the subject tolerating the position. The identical procedure was conducted to the other side (**figure 4**).

Figure 2. Muscle endurance evaluation of the trunk extensors using Biering-Sorenson test.

Figure 3. Muscle endurance examination of the trunk flexor muscles.

Figure 4. Muscle endurance examination of the trunk side flexor muscles using side bridge test.

Figure 5. Muscle endurance examination of the trunk extensors using prone double straight-leg raise test.

Prone double straight–leg raise test

The participant was asked to lie in a prone-lying position with the hips extended. The hands were held underneath the forehead. The arms were kept vertical to the body. Then the subject was instructed to lift off both legs until the knee clearance was achieved (20). The test continued as long as the participant kept the position. The endurance time was calculated in seconds (**figure 5**).

Statistical analysis

The Kolmogorov-Smirnov test was applied to check the data normality. Analysis of covariance (ANCOVA) was conducted to compare the trunk muscles' endurance differences between two groups (with and without FHP) controlling the effects of gender, age and body mass index. Pairwise comparisons were conducted after Bonferroni adjustment. The Pearson correlation coefficient was determined using bivariate correlation to explore the relationships between CVA and endurance tests. The magnitudes of these correlations were considered as negligible (0.0 - 0.1), small (0.1 - 0.3), moderate (0.3 - 0.5), large (0.5 - 0.7), very large (0.7 - 0.9), or extremely large (0.9 - 1.0) (22). The significance level was set at $P < 0.05$. There were no missing data. All statistical analysis was performed using SPSS statistics version 17.

RESULTS

All of the eligible participants fulfilled the procedures. Participants' characteristics are presented in **table I**.

The endurance tests showed significant differences between two groups (Wilk's Lambda = 0.803; F (7, 86 = 3.021); P= 0.007; Eta- squared = 0.197). Pairwise comparisons revealed that trunk muscle endurance of extensors, flexors and lateral flexors were lower in the presence of FHP ($P < 0.05$) (**table II**).

There were positive correlations between FHP severity and trunk muscle endurance. The fair to moderate direct correlation was found between CVA and Sorenson score. The amount of correlation between CVA and trunk flex-

Table I. Demographic characteristics of participants in two groups with and without FHP.

	With FHP (n= 36)	Without FHP (n=61)
Age (y), mean ± SD	23.25 ± 1.70	23.33 ± 2.52
Height (cm), mean ± SD	171.57 ± 7.36	169.49 ± 7.64
Weight (Kg), mean ± SD	67.28 ± 8.82	65.47 ± 9.43
BMI (Kg/m2), mean ± SD	22.80 ± 2.66	22.73 ± 2.64
Craniovertebral Angle, Mean ± SD	45.64 ± 2.16	53.05 ± 3.14

* denotes significant differences between groups ($P < 0.05$); FHP: Forward head posture

Table II. Between-group differences for trunk muscle endurance in people with and without forward head posture.

	With FHP (n= 36) mean ± SD	Without FHP (n=61) mean ± SD	P-value
Biering-Sorenson test (second)	44.05 ± 4.58	67.65 ± 3.51	0.000*
Trunk flexor endurance test (second)	36.36 ± 3.66	48.95 ± 2.80	0.008*
Right Side bridge test (second)	35.49 ± 3.07	45.87 ± 2.36	0.009*
Left Side bridge test (second)	35.83 ± 3.03	44.08 ± 2.32	0.034*
Prone Double straight-leg raise test (second)	42.74 ± 3.15	54.49 ± 2.42	0.004*

* denotes significant differences between groups ($P < 0.05$); FHP: Forward head posture

Table III. The relationship between the results of muscle endurance tests and craniovertebral angle expressed as correlation coefficients.

Relationship	P-value	RP
Craniovertebral angle and trunk flexor endurance test score	0.010*	0.260
Craniovertebral angle and Biering-Sorenson test score	0.001*	0.334
Craniovertebral angle and prone double straight-leg raise test score	0.015*	0.247
Craniovertebral angle and right side bridge test score	0.020*	0.235
Craniovertebral angle and left side bridge score	0.045*	0.234

* denotes significant correlations ($P < 0.05$); n = 97

or and lateral flexor muscle endurance scores was almost fair and direct (**table III**). The score of the prone double straight leg raise test is also fairly correlated to the amount of the CVA.

DISCUSSION

In the current study, the trunk endurance tests demonstrated significant differences between two groups of people with and without FHP. The trunk muscle endurance was lower in subjects with FHP compared to subjects without FHP. There were also negative relationships between the FHP severity and trunk muscle endurance.

The abnormal posture may be a predisposing factor in disability (23). FHP as a common poor posture is defined as the anterior position of the head in relation to the base of the neck and characterized by hyper extension of the upper cervical spine and flexion of lower cervical spine (24). Previous studies reported that FHP has effects on pain and disability, especially in the head, neck and shoulder region (3, 4, 23). The results of the present study are in accordance with others who examining the effects of adopting different head postures on trunk and lumbar muscle function (6). The activation of the sternocleidomastoid, external obliques and lumbar erector spinae muscles during moderate intensity lifting was higher when adopting retracted neck posture (*e.g.* chin tucks) compared to the freestyle neck posture in 7 participants with no history of low back pain. Decreased activity in the neck and trunk dorsal muscles was also associated with retracted neck posture (6). Therefore, the hyperextension of the upper cervical spine seen in FHP may contribute to the lower endurance of trunk and back muscles and eventually may predispose people to the back injury in the future when doing high demanding tasks such as lifting. Compared with our results, Yu (7), *et al.* reported that maintaining head flexion in prone bridging exercise can facilitate the abdominal muscle activity and enhances the treatment effect of prone bridging exercise. On the other hand, the activity of the lumbar multifidus muscles is higher during head extension compared to the neutral head position (7). Dejanovic (25), *et al.* also showed that adding cervical extension to the Biering-Sorenson test in children resulted in higher back endurance scores compared to the cervical flexion (25).These findings reveal that FHP may have effects on the lumbar and trunk muscle performance in different ways and depends on functional situations. Conversely, acquiring a slump sitting position imposes an anterior translation to the head and increases the activity of cervical extensors compared to the upright sitting (9). In this situation, the activation of superficial lumbar multifidus and internal oblique muscles is also diminished (26).

Therefore, there is a linkage between the alignment of the spine and muscular performance in different spinal levels. Furthermore, a randomized clinical trial demonstrated that adding corrective exercises to reduce FHP causes a decrease in symptoms of people suffering from chronic lumbosacral radiculopathy who had FHP concurred (27). It is also worthy to consider that FHP severity is related to the balance disturbances in healthy computer users (5) and the FHP is commonly present in patients with acute low back pain (23). Therefore, it can be concluded that habitual head posture is an important factor affecting the trunk and lumbar muscle performance maintaining neutral spine (28). We suggest examining the effects of FHP on trunk and lumbar muscle performance in various de-stabilizing conditions of the lumbar spine.

The prone double straight-leg raise test and the Sorenson test are the two most common procedures to assess the back extensor muscle endurance (20). According to McIntosh (20) *et al.*, the endurance of lower back extensor muscles can be assessed by prone double straight-leg raise test while the upper back extensors can be assessed by the Sorenson test (20). Decreased scores of the Sorenson endurance test is considered as a risk factor for low back pain (LBP) episodes (29). While, the prone double straight-leg raise test has the highest sensitivity, specificity, and predictive value of low back pain among Iranian people (30). Based on the results of the current study, the negative relationship between Sorenson test and FHP severity reveals that having abnormal head posture may be a contributing factor to the development of low back pain in the future. However, the amount of this relationship is fair to moderate. It may be due to low severity of the FHP in our participants. Evaluating these relationships based on the wider ranges of FHP severity is recommended (24).

The quadratus lumborum muscle function can be assessed by lateral bridge test (31). Cholewicki (25) *et al.* stated that the quadratus lumborum muscle is a major stabilizer of the lumbar spine while applying minimal loads on the lumbar spine (28). As shown before, young male elite golfers with low endurance scores on the side-bridge test are more likely to report future episodes of moderate and severe low back pain (32). The negative relationship between the FHP and trunk flexor muscle endurance can also be explained by the results reported by Su (33) *et al.* They found the higher activity level of abdominal muscles in crook-lying position adopting a craniocervical flexion position (33). Overall, Consistent with the findings of the current study, Hlavenka (6) *et al.* reported that adopting retracted head posture leads to increase in the activity of the lumbar erector spinae and external oblique muscles. This posture is considered as a safe strategy to perform lifting tasks (6). Altogether, it is recommended to identify the long-term effects of habitual abnormal postures on spinal muscle function because there are linkages between different parts of the spine. This information can give us better insight into the understanding of possible causes of postural pain disorders of the spine. Also, the significant difference in trunk muscles endurance between groups with and without FHP highlights the importance of screening postural imbalance in populations without obvious clinical manifestations to be enabled in designing preventive strategies to minimize injury risks in the spine. Finally, more research in this concern is needed to explore the cause-and-effect relationships between spinal muscular performance and postural mal-alignments.

Our study has some limitations. First, relatively young participants were included in this study. Of course, the possible effects of gender and age were controlled. In this regard, the severity of FHP is age dependent (11). Therefore, the age effect should be considered in the future studies. Second, the physical activity level is also an important factor influencing the muscular performance including endurance tests. We excluded people doing regular sport-specific exercises. Investigating the effect of FHP and other postural impairments on athletes' muscular performance may have implications for reducing athletic injuries in the future.

In conclusion, the lower endurance of trunk muscles in people with FHP compared to people without FHP predicates the importance of assessing the muscular performance at different levels of the spine in the presence of FHP. The negative relationships between FHP severity and trunk muscles endurance, demonstrate that the muscle endurance is related to the alignment of the spinal column. These findings may have implications to design preventive strategies for people with poor postures and reduce the risk of injury in the future.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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