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Original Article

Effects of forward head posture on forced vital capacity and respiratory muscles activity

Jintae Han, PT, PhD[1)], Soojin Park, PT, PhD[1)*], Youngju Kim[2)], Yeonsung Choi[1)], Hyeonnam Lyu[1)]

[1)] *Department of Physical Therapy, College of Science, Kyungsung University: 309 Suyeong-ro, Nam-gu, Busan 608-736, Republic of Korea*
[2)] *Department of Physical Therapy, Graduate School of Clinical Pharmacy and Health, Kyungsung University, Republic of Korea*

Abstract. [Purpose] This study investigated the effects of forward head posture on forced vital capacity and deep breathing. [Subjects] Twenty-six subjects, divided into the two groups (normal and forward head posture groups), participated in this study. [Methods] Forced vital capacity and forced expiratory volume in 1 second were measured using respiratory function instrumentation that met the American Thoracic Society's recommendation for diagnostic spirometry. Accessory respiratory muscle activity during deep breathing was measured by electromyography. A Mann-Whitney test was used to compare the measure variables between the normal and forward head posture group. [Results] Forced vital capacity and forced expiratory volume in 1 second were significantly lower in the forward head posture group than in the normal group. Accessory respiratory muscle activity was also lower in the forward head posture group than in the normal group. In particular, the sternocleidomastoid and pectoralis major activity of the forward head posture group was significantly lower than that of normal group. Activities of the other muscles were generally decreased with forward head posture, but were not significantly different between the two groups. [Conclusion] These results indicate that forward head posture could reduce vital capacity, possibly because of weakness or disharmony of the accessory respiratory muscles.
Key words: Forward head posture, Forced vital capacity, Breathing muscle activity

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INTRODUCTION

In recent times in some occupations work in static sedentary postures for long hours in order to perform the tasks required of them. This can cause continuous muscle contraction in the neck and shoulders, which subsequently leads most people to adopt a forward head posture (FHP) in which their chins stick out[1)].

When FHP is maintained for prolonged periods the neck flexors and the erector spinae (ES) muscles in the upper thoracic region are weakened due to their lengthening, and the scapula is elevated due to tension in the levator scapula, sternocleidomastoid (SCM), splenius muscles, and the suboccipitalis, which also causes tension in the upper trapezius (UT)[2)]. Therefore, because of an imbalance in the muscles, such as the shortening or lengthening, or straining or loosening of the muscles around the neck, a rounded shoulder posture is exhibited, in which the upper thoracic region is slightly bent while in a sitting posture[3)], and chronic neck pain results due to mechanical stress[1)]. These changes in muscle activity result from changes in motor strategies to minimize the activities of muscles that are sensing pain and to compensate for these suppressed muscles[4)].

In addition, FHP is known to have a large influence on respiratory function by weakening the respiratory muscles[5, 6)]. The SCM, scalene muscles, UT, pectoralis major (PM), and thoracolumbar ES muscles are important accessory respiratory muscles involved in inspiration[7, 8)] and prolonged FHP weakens these muscles, thereby decreasing their respiratory function[7)].

*Corresponding author. Soojin Park (E-mail: rememversj@hanmail.net)

Because of this, patients with FHP accompanied by chronic neck pain have been shown to have less respiratory muscle strength than normal individuals[9] and their accessory respiratory muscles are shortened, which largely affects their respiratory function[10]. In addition, a study reported that FHP changes the alignment of the thoracic spine and rib cage due to a slightly bent posture, thereby causing respiratory dysfunction[5].

However, most previous studies on this topic were conducted on patients with neck pain or on patients with neck pain accompanied by FHP, whereas the number of studies that have identified the specific effects of just FHP on respiration is limited. Therefore, this study measured the forced vital capacity (FVC) and the forced expiratory volume in 1 second (FEV1) in healthy normal adults and healthy adults with FHP to determine the effects of FHP on respiratory dysfunction. In addition, the present study attempted to determine the relationship between FHP and accessory respiratory muscle activity by measuring the activity of the SCM, UT, PM, and thoracolumbar ES muscles during deep breathing.

SUBJECTS AND METHODS

Twenty-six subjects (14 males, 12 females) participated in this study. They were divided into the two groups: normal group and FHP group. Because lung capacity and muscle activity differ between the genders[11], results between the normal and FHP groups were compared separately for males and females. Before participation in this study, all subjects signed an informed consent document that was approved by the Institute Research Board of Kyungsung University. FVC, FEV1, and accessory respiratory muscle activity during deep breathing were measured for each group. To measure FVC and FEV1, the subjects are asked to perform a rapid full inspiration through the mouthpiece and then, without hesitation, perform a full expiration with maximum force, followed by another rapid maximum inspiration. FVC and FEV1 were measured using pulmonary function equipment (Spiropalm, Cosmed, Italy) that met the American Thoracic Society's recommendation for diagnostic spirometry.

An electromyography unit (Telemyo direct transmission system, Noraxon, USA) was used to measure the activity of the following accessory respiratory muscles during deep breathing: SCM, UT, PM, and ES muscles. Data are expressed as percentages of the reference voluntary contraction (% RVC). Muscle activity was measured during the inspiration and expiration phases.

A Mann-Whitney test was used to compare the FVC, FEV1, and breathing muscle activity between the normal and FHP group. SPSS software (version 21.0; SPSS, Chicago, IL, USA) was used to generate the statistics, and p-values less than 0.05 were considered statistically significant.

RESULTS

The characteristics of the subjects are shown in Table 1. The craniovertebral angle was significantly different between normal and FHP subjects in both males and females ($p < 0.05$ for both genders). FVC and FEV1 of the FHP group were both significantly lower than they were in the normal group, in both males and females ($p < 0.05$ for both genders) (Table 2). Activity of the SCM and PM in the FHP group was significantly lower than that of the normal group in males ($p < 0.05$).

Table 1. Subject characteristics (mean±SD)

Variable	Group			
	Male (n=14)		Female (n=12)	
	Normal (n=7)	FHP (n=7)	Normal (n=5)	FHP (n=7)
Age (years)	23.3±2.2	24.2±3.6	22.8±0.3	23.2±2.8
Height (cm)	174.6±8.5	176.7±8.9	161.4±4.2	162.9±5.4
Weight (kg)	70.1±8.2	72.6±5.5	54.3±5.6	53.9±4.6
CVA (°)	53.1±2.3	40.9±4.0	55.4±2.1	43.1±2.5

SD: standard deviation, FHP: forward head posture, CVA: craniovertebral angle

Table 2. Comparisons of FVC and FEV1 between normal and FHP subjects (mean ± SD)

Variable	Group			
	Male (n=14)		Female (n=12)	
	Normal (n=7)	FHP (n=7)	Normal (n=5)	FHP (n=7)
FVC	4.6±0.4	3.9±0.3*	3.2±0.2	2.7±0.4*
FEV1	4.5±0.4	3.6±0.4*	3.2±0.4	2.5±0.4*

*p < 0.05. SD: standard deviation, FHP: forward head posture, FVC: forced vital capacity, FEV1: forced expiratory volume at 1 second

Activity of the UT and ES in the FHP group was generally lower than that of the normal group in men but the difference was not significant ($p > 0.05$) (Table 3). Activity of the SCM, PM, and UT in the FHP group was significantly lower than that of the normal group in women ($p < 0.05$). The activity of the ES in FHP group was generally lower than that of the normal group in women but the difference was not significant ($p > 0.05$) (Table 3).

DISCUSSION

The present study measured FVC and FEV1, as well as the muscular activity in the SCM, UT, PM, and ES muscles during inspiration to identify the effects of FHP on vital capacity and the activity of the accessory respiratory muscles. The FHP group showed statistically significantly lower FVC and FEV1 levels than the normal group. In terms of the activity of the accessory respiratory muscles, the FHP group also exhibited statistically significant decreases in the activation of the SCM, UT, and PM relative to muscle activation in the normal group. While the FHP group did not show a significant decrease in the ES muscle's activity, its activity in this group was generally lower than in the normal group.

FHP causes shortening and weakening of the accessory respiratory muscles, thereby decreasing the ratio of FEV1 to FVC[10]. Kapreli et al. reported that an increase in FHP resulted in a corresponding increase in respiratory dysfunction[6]. In addition, even among the subjects without neck pain, an increase in FHP led to a corresponding statistically significant decrease in vital capacity[3].

Dimitriadis et al. reported that maximal inspiratory and expiratory pressure showed statistically significant decreases for complex reasons, such as weaknesses of the SCM, scalene muscles, and the trapezius, which are accessory respiratory muscles, and a reduction in kinetic control of the cervical area[9]. In addition, Wirth et al. reported that weaknesses of the neck muscles and accessory respiratory muscles in patients with neck pain resulted in a decline in thoracic mobility, thereby decreasing maximal voluntary ventilation, maximal inspiratory pressure, and maximal expiratory pressure, and that these effects were closely related to FHP[12]. However, some studies reported that an increase in FHP resulted in a corresponding increase in maximal expiratory pressure[6, 9]. This result may be explained as follows: while FHP represents an abnormal posture, this posture can increase the trunk's internal pressure during expiration and therefore may increase dynamic mechanisms. In the present study, the observed decrease in FEV1 may have been due to increased kyphosis in the upper thoracic region, which is characterized by FHP, causing a reduction in the volume of the thoracic cage. This would not only reduce the expiratory reserve volume, but also create resistance to the exhalation.

In general, respiration is an activity influenced by complex biomechanical factors and the stability of the cervical and thoracic regions of the spine is of great importance to smooth respiratory function[5]. However, FHP causes the shortening and weakening of the SCM, scalene muscles, trapezius, and ES muscles[7], and therefore, reduces the endurance and proprioception of these muscles[5]. In addition, FHP increases muscle tension around the thoracic spine, thereby restricting the range of motion in the upper thoracic spine[3].

The present study compared normal adults without neck pain based on the presence or absence of FHP. The results were similar to those of a number of previous studies on patients with FHP and neck pain, as well as those of the previous studies on normal adults with FHP but without neck pain[3]. The results presented here may be important in confirming that FHP without neck pain can still influence respiration. Therefore, when treating patients with FHP or lung dysfunction, improvements in respiratory function through the correction of posture and the strengthening of weakened accessory respiratory muscles may be clinically important.

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Table 3. Comparisons of respiratory muscle activity between normal and FHP subjects (mean ± SD)

Variable	Group			
	Male (n=14)		Female (n=12)	
	Normal (n=7)	FHP (n=7)	Normal (n=5)	FHP (n=7)
SCM	816.6±350.0	353.3±192.0*	1,243.6±762.2	514.2±123.0*
UT	273.2±114.3	177.5±39.7	596.6±350.6	244.8±103.0*
PM	274.8±95.7	183.6±39.4*	290.8±68.2	200.3±67.9*
ES	197.1±71.3	184.2±37.4	229.0±82.5	171.1±53.9

*$p < 0.05$. SD: standard deviation, FHP: forward head posture, SCM: sternocleidomastoid, UT: upper trapezius, PM: pectoralis major, ES: erector spinae

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