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REVIEW

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The effect of forward head posture on dynamic lung volumes in young adults: a systematic review

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Abstract

Purpose The study aimed to investigate whether there is a difference in pulmonary function between individuals with forward head posture and those with neutral head posture.

Methods A systematic search was conducted using the ResearchGate, PubMed, and Scholar databases following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. The eligibility criteria for the studies were that they investigated the relationship between Forward Head Posture (FHP) and Forced Vital Capacity (FVC) and/or Forced Expiratory Volume in one second (FEV1).

Results A total of four comparison studies and two correlation studies met the inclusion criteria for this study. Across these four studies, encompassing a total of 115 participants, the observed reduction range for FVC was between -0.25 L and -0.81 L, while the reduction values for FEV_1 ranged from -0.16 to -0.93 L. According to the results of the correlation studies, a positive correlation was observed between craniovertebral angle (CVA) and dynamic pulmonary volumes.

Conclusion The existing evidence indicates that FHP can potentially cause abnormalities in pulmonary function. In this context, it is suggested that individuals with FHP should be monitored for changes in pulmonary function.

Keywords Forward head posture, Pulmonary function, Forced vital capacity, Forced expiratory volume

Introduction

The standard sagittal alignment for the cervical region is defined as a posture in which specific reference points, such as the external auditory meatus, the seventh cervical vertebra, and the acromion, are aligned in a specific position relative to the line of gravity. These reference points provide a framework for assessing proper alignment and evaluating deviations from the norm in the cervical region. One of the most commonly observed sagittal alignment disorders in the cervical region is forward head posture (FHP) [1]. FHP is defined as the anterior displacement of the head in the sagittal plane relative to the gravity line [2]. The severity of forward head posture is often assessed using the craniovertebral angle (CVA), which is measured by drawing a horizontal line passing through the spinous process of the seventh cervical vertebra (C7) and connecting the midpoint of the tragus to the C7 prominence [3, 4]. The CVA and the severity of FHP are inversely proportional, this means that as the CVA decreases, the severity of FHP increases [5, 6]. In numerous studies, a CVA measuring less than 48°has been established as a standard criterion widely accepted to confirm the presence of FHP [7–9].

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FHP exhibits a specific kinematic characteristic with hyperextension in the craniocervical joint and flexion in the subaxial cervical spine [10, 11]. In the literature, it is acknowledged that the FHP is associated with the weakening and elongation of the upper cervical flexors and lower cervical extensor muscles, as well as the shortening of the upper cervical extensor and lower cervical flexor muscles [8]. In a study investigating the differences in muscle strength between individuals with FHP and those with Normal Head Posture (NHP), it was observed that there was no significant difference in muscle strength for both upper cervical extensors and lower cervical flexors between the two groups. However, it has been reported that in individuals with FHP, the lower cervical extensor muscle strength, which is 9.3 N/kg%, is lower compared to the 12.7 N/kg% observed in individuals with NHP. Additionally, it was noted that the upper cervical flexor muscle strength in the FHP group was 7.1 N/kg%, while in the NHP group, it was 9.4 N/kg%, and statistical significance was reported [8]. The presence of these specific kinematic and kinetic changes in individuals with FHP is consistent with the study that investigated kinetic changes in individuals with FHP, involving six human cadavers and reporting a reduction in the length of the occipital extensors and cervical flexors [12].

In an ultrasound imaging study, the thickness of the sternocleidomastoid (SCM) and rectus capitis posterior major muscles in the FHP group and the control group were examined. The study revealed a statistically significant difference in SCM muscles thickness between the two groups. The control group exhibited an average thickness of 8.05 mm, while the FHP group showed an average thickness of 8.7 mm [7]. In another study, the thickness of the SCM muscle was investigated in individuals with FHP in a relaxed head position and a horizontal head position, and these measurements were compared with those of asymptomatic individuals. The findings of this study have demonstrated that there is no significant difference in muscle thickness in the relaxed head position between the two groups. However, in the group with FHP, a statistically significant increase in the thickness of the SCM muscle has been reported in the horizontal head position, as compared to the subjects without FHP [13].

Studies investigating muscle activations in individuals with FHP using electromyography have reported statistically significant alterations, particularly in the activations of the SCM, trapezius, and serratus anterior muscles [14–16]. It is known that individuals with FHP exhibit an increase in the activation of the SCM muscle, as well as an increase in the activation of the upper and lower trapezius muscles to compensate for the decreased activation of deep flexor muscles. Consequently, changes in the tension of these muscles occur [17]. In several studies, it has been reported that kinetic functional impairments in these muscles lead to conditions such as rounded shoulders, rib cage abnormalities, and compensatory changes in the thoracic region during sitting. [18–20]. In a literature review study, it has been interpreted that the formation of FHP is related to the development of round shoulders and thoracic kyphosis, suggesting a mutual triggering of these conditions [21]. As additional evidence, in a study involving elderly participants with an average age of 66, a relationship between FHP and thoracic kyphosis has also been confirmed [22].

On the other hand, SCM and upper trapezius muscles are not only involved in neck mobility but also play a crucial role as inspiratory muscles, along with the diaphragm, during forceful inhalation [1, 23]. It has been reported that due to the FHP, the shortening and weakening of accessory muscles, along with the imbalanced muscle forces during the forced inspiration of the thoracic cage, could potentially lead to the release of dynamic pulmonary volume [24, 25]. In a meta-analysis study investigating the relationship between chronic neck pain and FVC and FEV_1 (Forced Expiratory Volume in 1 s), standardized mean differences of 0.53 for FVC and 0.28 for FEV1 were reported in individuals with chronic neck pain [26]. Dynamic pulmonary volume is analyzed through the measurement of FVC and FEV_1 [27]. In this context, there are several studies investigating whether a reduction in dynamic lung volume exists among individuals with FHP by measuring FVC and FEV_1 values [28–30].

This study aimed to review existing research investigating differences in pulmonary function between individuals with FHP and asymptomatic individuals, aiming to enhance comprehension in this topic through current evidence.

Methods

Literature search strategy

A comprehensive review of the electronic literature was conducted by 2 investigators (YD, DE) using databases including ResearchGate, PubMed, and Google Scholar. The research timeframe spanned from 2010 to June 2023, with the scope of investigation limited to scholarly works conducted exclusively in the English and Korean languages. In the initial stage, the keywords were selected from MeSH terms and free keywords in a manner appropriate to this study's topic. Following this, various combinations of these identified keywords were created. The utilized keyword combinations encompassed the following terms: "head posture" OR "FHP" OR "forward head posture" OR "craniovertebral angle" OR "CVA" AND "forced vital capacity" OR "FVC" AND "forced expiratory volume" OR "FEV_1".

Selection criteria

The inclusion criteria for this study were defined as follows: (1) participants' mean ages were required to be between 18 and 30 years, (2) studies assessing head positions through CVA evaluation, (3) studies that obviously present FVC values, (4) studies providing a clear presentation of FEV_1 values. The exclusion criteria comprised the following: (1) studies involving participants with significant skeletal anomalies or diseases possessing the potential to impact pulmonary function (2) studies involving children among the participants, (3) studies published in languages other than Korean and English, and (4) studies involving participants with concurrent chronic neck pain.

Data extraction

Two authors (YD, DE) independently gathered information from each selected study, employing a standardized form that delineated the specific data items. The collected data were subsequently reviewed by other authors, and no instances of disagreement arose. In the second phase, the collected data were utilized to create tabulations under five subheadings.

Results

Study selection

In this study, the PRISMA guidelines were adhered to for the selection of appropriate articles, and the schematic representation is presented in (Fig. 1). A total of 2,163 studies were initially identified from electronic databases. Following a review of titles and abstracts, only 21 studies were found to be relevant to our objective, warranting a comprehensive full-text examination. Due to the lack of presentation of essential parameters, unavailability of access to the full text, and a lack of clarity regarding the general characteristics of the participants, the study was conducted with only six trials.

Study description

The characteristics of the participants in the studies and the overall results of each study are presented in (Table 1). In the four studies, out of a total of 115 participants, 56 were male. Among the correlation studies

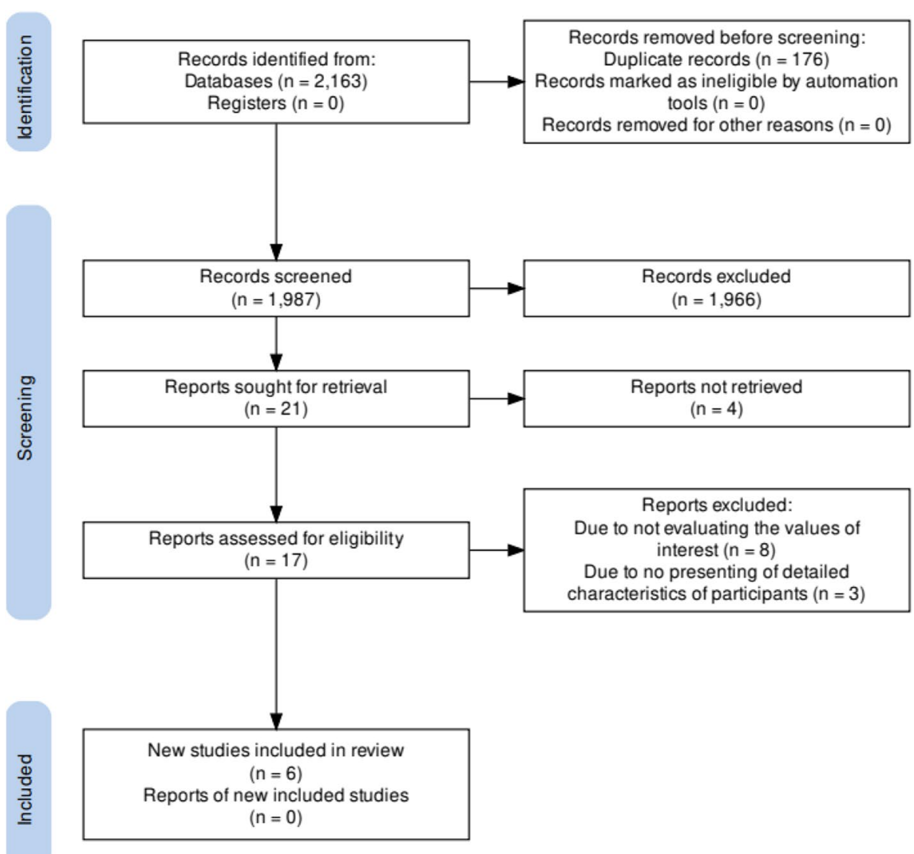

Fig. 1 PRISMA flowchart of study identification, screening, and eligibility

Table 1 General characteristics and summary of the results of the included studies

Study	Participant	Mean age Height Weight CVA	Exclusion criteria	Respiratory parameters	Summary of results
Han et al. (2015) [32]	**FHP** = 14 (7 male, 7 female) **NHP** = 14 (6 female, 8 male)	For male **FHP** 23 174.71 cm 70.14 kg 40.86° **NHP** 23 176 cm 71 kg 53.63° For female **FHP** 22.71 162.94 cm 53.27 kg 43.14° **NHP** 22.67 161.83 cm 54 kg 54.83°	Participants who had neuromuscular disease, tuberculosis, asthma, obesity, tumors	For male **FHP** FVC (L) = 3.82 L FEV_1 (L) = 3.61 L FEV_1/FVC = 92.68% **NHP** FVC (L) = 4.63 L FEV_1 (L) = 4.54 L FEV_1/FVC = 97.91% For female **FHP** FVC (L) = 2.90 L FEV_1 (L) = 2.60 L FEV_1/FVC = 90.43% **NHP** FVC (L) = 3.32 L FEV_1 (L) = 3.28 L FEV_1/FVC = 98.93%	In both men and women, significant differences were seen between groups for all respiratory parameters A reduction in all values was observed in the FHP group compared to the NHP group
Han et al. (2016) [28]	**FHP** = 14 (7 male, 7 female) **NHP** = 12 (7 male, 5 female)	For male; **FHP** 24.2 176.7 cm 72.6 kg 40.9° **NHP** 23.3 174.6 cm 70.1 kg 53.1° For female; **FHP** 23.2 162.9 cm 53.9 kg 43.1° **NHP** 22.8 176.7 cm 72.6 kg 55.4°	Not mentioned	For male **FHP** FVC (L) = 3.9 L FEV_1 (L) = 3.6 L **NHP** FVC (L) = 4.6 L FEV_1 (L) = 4.5 L For female **FHP** FVC (L) = 2.7 L FEV_1 (L) = 2.5 L **NHP** FVC (L) = 3.2 L FEV_1 (L) = 3.2 L	In the presence of forward head posture in both women and men, both FVC and FEV_1 values were significantly reduced Muscle activities of SCM and PM lower than NHP groups

Table 1 (continued)

Study	Participant	Mean age Height Weight CVA	Exclusion criteria	Respiratory parameters	Summary of results
Kim et al. (2013) [33]	**FHP** = 20 (7 male, 13 female) **NHP** = 26 (5 male/ 21 female)	**FHP** 21.4 167.3 cm 59.3 kg 46.0° **NHP** 21 165.5 cm 57.5 kg 54.2°	Participants with deformity of chest or spine, tumors, chest surgery	**FHP** FVC (L) = 3.46 L FEV_1 (L) = 3.28 L FEV_1/FVC = 94.75% **NHP** FVC (L) = 3.74 L FEV_1 (L) = 3.44 L FEV_1/FVC = 92.27%	No statistically significant results were found in the comparison between groups. However, the predicted values of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio were found to be statistically significant
Koseki et al. (2019) [31]	**NHP** = 15 (15 male)	26.8 170 cm 65.3 kg	Neck or respiratory diseases or traumas, spinal deformations, history of smoking	**FHP position** FVC (L) = 4.19 L FEV_1 (L) = 3.55 L **NHP** FVC (L) = 4.44 L FEV_1 (L) = 3.78 L	Statistically significant differences were observed in the comparison between groups for all measured parameters. Furthermore, decreased lower thoracic mobility has been observed
Kang et al. (2018) [30]	**FHP** = 24	**FHP** 29.5 169.5 cm 64.7 kg 45.7°	Congenital anomalies in neck, neurological disorders, and limitations in hip joint	Correlation between CVA and FVC $r = 0.63$ CVA and FEV_1 $r = 0.31$ CVA and FEV_1/FVC $r = 0.21$ CVA and SCM activity $r = -0.77$	A statistically significant positive correlation was observed between FVC and CVA. However, no statistically significant correlation was found between FEV_1 and CVA. There were negative correlation between SCM activity and CVA
Kim et al. (2017) [29]	**FHP** = 33	21.5 165.6 cm 59.6 kg 48.94°	Acute or chronic respiratory diseases, anomalies in chest or spine	Correlation between CVA and VC $r = 0.58$ CVA and FVC $r = 0.53$ CVA and FEV_1 $r = 0.54$ CVA and SCM activity $r = -0.47$ CVA and UT activity $r = -0.15$	A significant positive correlation was found between CVA and pulmonary function parameters, while a negative correlation was observed between SCM muscle activation

FHP Forward head posture, *NHP* Neutral head posture, *CVA* Craniovertebral angle, *FVC* Forced vital capacity, *FEV1* Forced Expiratory Volume in one second, *VC* Vital capacity, *SCM* sternocleidomastoid, *UT* Upper trapezius involving 57 participants, no information was provided regarding gender. In the sixth study, the average age of the 172 participants was calculated to be 23,5. The mean CVA for participants with FHP in the four studies was calculated to be 43,67. In Koseki's study, only healthy individuals were included, and measurements were taken after individuals were instructed to assume a forward head posture [31]. The FHP and NHP groups were distinguished using craniovertebral angle in all studies.

Outcomes

In three comparative studies, significant statistical decreases in FVC and FEV1 values among individuals with FHP have been reported [28, 31, 32]. In another study, while a significant decrease in dynamic lung volume was not observed, significant changes in predicted parameter values were reported [33]. The reduction in FVC was measured to range between 0.25 to 0.81 L, while the reduction in FEV1 was reported to potentially range between 0.16 to 0.93 L. In two studies focusing solely on females, the reduction in FVC was reported to be 0.42 and 0.5 L, while for FEV_1, it was determined to be between 0.68 and 0.7 L. For males only, the reduction in FVC was reported to range between 0.81 and 0.7 L, while the reduction in FEV_1 was reported to range between 0.93 and 0.9 L [28, 32].The forest plot illustrating the comparison of pulmonary function between the FHP group and the control group is presented in (Fig. 2). The correlation coefficient between CVA and FVC was reported as $r=0.63$ and $r=0.53$ in two studies, while the correlation coefficient between CVA and FEV_1 was reported as $r=0.31$ and $r=0.54$ [29, 30]. The change in the FEV_1/FVC ratio was reported as -8.5% for females and -5.23% for males. However, in another study where both females and males were analyzed together, the change in this ratio appeared to increase by 2.48%. A significant decrease in the FEV_1/FVC ratio was reported, with a p-value of 0.02 for males and 0.04 for females [32]. However, in the study where an increase in the ratio was observed, it was reported that no statistically significant

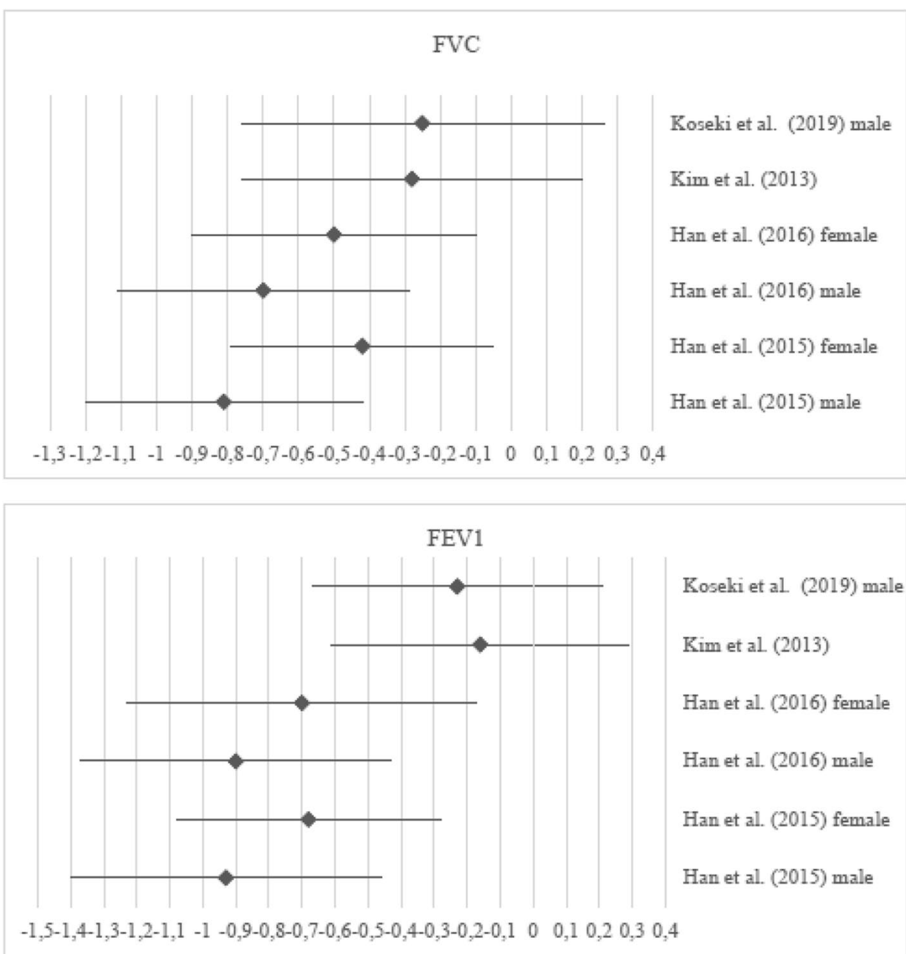

Fig. 2 Forest plot for the mean differences of dynamic lung volumes between individuals with FHP and asymptomatic individuals

change in the FEV_1/FVC ratio when comparing the two groups, the FHP group, and the control group [33].

Discussion

The goal of this study was to provide a better understanding of the impact of FHP on pulmonary function. We included a total of six studies, including this systematic review, to ascertain the presence of pulmonary dysfunction by examining the FVC and FEV_1 values. Among these, two studies were correlation studies, and therefore, for the purpose of observing inter-group volume differences, only four studies were incorporated. Within the scope of these studies, it has been concluded that individuals with FHP may experience a reduction in forced vital capacities ranging from 0.25 to 0.81 L. In a separate investigation examining losses in males and females, a study reported that the FVC, which is 4.6 L in normally headed postured (NHP) males, decreased to 3.9 L in FHP males, resulting in a loss of 0.7 L. The same study reported that among NHP females, the FVC was 3.2 L, whereas in FHP females, it decreased to 2.7 L, indicating an overall loss of 0.5 L. Despite the disparity in reported male and female loss values in this study's findings, when examined as percentages, it was observed that both males and females experienced an average loss of approximately 15% [28]. In Köseki's study, only healthy males were included, and measurements were taken by altering the head position of these healthy males. An average loss of 0.25 L was reported. Compared to the other two studies, this study's findings indicate a lesser degree of loss. Consequently, it was speculated that true individuals with FHP might be susceptible to enduring permanent pulmonary dysfunction. In a study, it was reported that a decrease in lung volume alters the elastic properties of lung tissue, implying that this long-term effect could lead to permanent changes in lung tissue [34]. Furthermore, the same study reported a significant reduction in lower thorax mobility in the anteroposterior direction. A study conducted on individuals with FHP identified an approximate 1 cm reduction in diaphragm excursion during deep breathing, substantiating the findings of Köseki's research. In this study, where 30 participants were involved, with 13 of them being male, the measured diaphragm mobility in the healthy group was 66.70 mm, whereas it was measured as 56 mm in the FHP group. This situation was interpreted as an approximate 15% decrease in diaphragm mobility [35]. It has been reported that individuals with FHP exhibit reduced diaphragm muscle strength and decreased mobility, suggesting that even a short duration of FHP may compress the phrenic nerve, thereby diminishing neural activity and consequently leading to a reduction in lung volumes [36–38]. It has been reported that reduced mobility in the lower thorax can impact inspiratory capacity, thereby affecting FVC and inspiratory reserve volume (IRV). Additionally, it has been noted that the kyphotic expansion in the upper thorax due to FHP may lead to increased resistance during expiration, potentially resulting in decreased FEV_1 and expiratory reserve volume (ERV) [28, 32].

In this study, while statistical significance was observed for the FEV_1/FVC ratio in one investigation, a generalization could not be made as such significance was not observed in another study [30, 32]. In Solakoğlu's study, a weak negative correlation for this parameter was reported in individuals with forward head posture and chronic neck pain [20]. The lack of a significant alteration in the FEV_1/FVC ratio in individuals with FHP has been attributed to a concurrent reduction in both FEV_1 and FVC values. In the study of Oh et al., it was concluded that there was no significant relationship between CVA and the FEV_1/FVC ratio. However, the lack of a statistically significant correlation between FEV_1, FVC values, and CVA contradicted the findings of the three studies included in our research. The study, involving 50 participants, did not explicitly present the mean CVA value. Consequently, we interpreted the absence of a significant correlation between dynamic lung volume and CVA as potentially stemming from the participants' lower severity of FHP compared to other studies [39].

Furthermore, in our study, we investigated alterations in the activation of accessory muscles associated with FHP, conducting three separate investigations. The outcomes of these three studies collectively revealed a significant change in the activation of the SCM muscle. Additionally, one study reported changes in the activation of the pectoralis major and upper trapezius muscles, while in the other two studies, alterations in the activation of the anterior scalene muscle were documented [28–30]. As a result, in individuals with FHP, the observed biomechanical alterations in these accessory muscles, coupled with limited diaphragmatic mobility, have been interpreted as exerting a potentially restrictive effect on the lungs during challenging respiration. Our proposition is that due to the potential of this restriction to lead to a persistent impairment if left untreated, the inclusion of respiratory rehabilitation in the treatment protocol for individuals with FHP should be contemplated as necessary in appropriate cases.

In this study, the absence of an evaluation of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) values, which assess respiratory muscle strength, has been recognized as a limitation in order to reconsider the impact of FHP on muscle strength. Additionally, pulmonary volume values vary according to gender, and the lack of a detailed examination based on gender constitutes a deficiency in the study. Another limitation of our study was the inability to investigate how static lung volumes are impacted by the forward head posture.

Conclusion

The findings suggest that the FHP exerts a negative impact on dynamic lung volumes by altering the biomechanics of the diaphragm and accessory muscles. However, the present study did not investigate the effects of FHP on respiratory muscles. We recommend that future research examine the values of maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) in individuals with forward head posture.

Abbreviations

FHP Forward head posture
FVC Forced vital capacity
FEV_1 Forced expiratory volume in one second
CVA Craniovertebral angle
NHP Normal head posture
SCM Sternoclediomasteoid

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Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All authors involved in this work have provided their consent for the submission and publication of this study.

Competing interests

Not applicable.

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