Differences in abdominal muscle activation during coughing between smokers and nonsmokers

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Abstract. [Purpose] The purpose of this study was to compare the activity of the abdominal muscles during coughing between smokers and nonsmokers. [Subjects] A total of 30 healthy adults (15 smokers, 15 nonsmokers) participated. [Methods] The percentage maximal voluntary isometric contraction values (%MVIC) of the rectus abdominis (RA), external abdominal oblique (EO), and internal abdominal oblique (IO) and transversus abdominis (TrA) were measured using surface electromyography. [Results] The %MVIC of the IO and TrA statistically significantly differed and the %MVIC of IO and TrA was found to be higher during coughing in nonsmokers compared with during coughing in smokers. [Conclusion] The activity of the deep abdominal muscles in nonsmokers was also higher than that of smokers during coughing.

Key words: Smoking, Cough, Abdominal muscle activation

INTRODUCTION

Smoking affects the circulatory and respiratory systems of the human body diversely. Chronic cough is one of diseases that result from smoking, as about 50% of those who smoke more than a pack of cigarettes per day have chronic coughs. Furthermore when smokers stop smoking temporarily, their coughs occur more frequently because the cough reflexes increase1). A cough reflex is the body’s defense mechanism that prevents any harmful materials from entering the airway and removes secretions from the airway2). In order to perform a cough, strong contraction of the expiratory muscles is required3). At this time, the expiratory muscles are composed of abdominal muscles, transversus thoracis muscles, and intercostal muscles. The abdominal muscles among the expiratory muscles include the rectus abdominis (RA), external abdominal oblique (EO), internal abdominal oblique (IO) and transversus abdominis (TrA).

In an intriguing study, Kim4) compared abdominal muscles playing a great role in the process of cough between smokers and non-smokers, where the thickness changes of abdominal muscles at exhalation were greater in nonsmokers than smokers, which may in turn affect their spinal stabilization4). In another study, which compared the cross-sectional areas of the muscles of smokers and nonsmokers, the cross-sectional areas of smokers were found to have decreased by about 22% compared with those of nonsmokers5). Therefore, though the effect of smoking on the circulatory system and the respiratory system is already well known, research on the functional changes of the musculoskeletal system resulting from smoking, or in particular, research on smokers’ musculoskeletal changes during coughing deeply related to airway cleanliness, has been lacking. Accordingly, this study aimed to compare the activities of the abdominal muscles during coughing between smokers and nonsmokers.
SUBJECTS AND METHODS

This study involved 30 healthy adult males (15 smokers, 15 nonsmokers) who sufficiently understood the purpose and method of the study and consented to participate in the experiment. The mean age, mean height, mean weight, and mean smoking duration of the smokers were 28.40±1.10 years, 174.27±1.04 cm, 73.33±2.33 kg, and 8.67±1.12 years. The mean age, mean height, mean weight, and mean smoking duration of the nonsmokers were 30.80±10.00 years, 173.60±1.18 cm, 70.13±2.53 kg, and 0.00±0.00 years. This study was approved by the Institutional Review Board of Pusan National University Hospital (E-2014105). The abdominal muscle activation of the subjects during voluntary coughing was measured three times while they were in an upright standing position. Surface electromyography (sEMG, Telemyo 2400, Noraxon, USA) was used to measure the activity of the abdominal muscles, including the RA, EO, and IO and TrA. To measure the RA, an electrode was attached along the muscle fiber 2 cm lateral from the navel. To measure the EO, an electrode was attached to 1/2 area between the anterior superior iliac spine (ASIS) and costa. For the IO and TrA, an electrodes were attached 2 cm medial from ASIS and 2 cm below the ASIS along the muscle fiber. In order to standardize sEMG signals into maximum voluntary isometric contraction (MVIC), the MVIC for each muscle based on the manual muscle test was measured for 10 seconds. In order to minimize muscle fatigue, which may have occurred due to continuous measurements, the subjects were allowed to rest for 10 minutes after each exercise. The results of this study were analyzed with a significance level at α=0.05 using IBM SPSS Statistics for Window version 20. The homogeneity of the two groups and their abdominal muscle activation values were analyzed with the independent t-test.

RESULTS

Table 1 displays the abdominal muscle activation of smokers and nonsmokers. The %MVIC of the smokers’ IO and TrA was 11.13%, and that of the nonsmokers’ IO and TrA was 19.07%, with the %MVIC of nonsmokers being statistically significantly higher. On the other hand, the %MVIC of the RA and EO did not significantly differ between the two groups.

DISCUSSION

Smoking causes bronchial cilia dysmotility and inhibits proliferation of the mucinous exocrine gland. It inhibits the lungs’ macrophage functions and triggers bronchial hypersensitivity resulting from histological changes of the bronchus. Therefore, smokers discharge more secreta than nonsmokers within the bronchus, and in order to remove secreta, they cough much. Accordingly, the aim of this study was to compare activity of the smokers’ and nonsmokers’ abdominal muscles during coughing.

The activation of the IO and TrA, which plays an important role in elevation of the abdominal pressure, in this research was higher in the nonsmokers compared with the smokers, and it showed a statistically significant difference (p=0.00). In addition, although there was no statistically significant difference, the superficial layer of the RA in smokers tended to be about 21% more activated compared with nonsmokers. Kaneko, Sato, Maruyama compared to the thickness of the muscle contraction EO, IO, TrA according to the resistance during exhalation in normal adults. They reported that deep muscle contraction highly contributed to the entire abdominal muscle contraction during expiratory resistance. Kim, Kim compared the contraction thickness of the abdominal muscles between smokers and nonsmokers. They reported that contraction was much higher in nonsmokers than smokers about 1.6 times. According to the results regarding the activity of the abdominal muscles during coughing in the present study, nonsmokers used relatively deep abdominal muscles more often than smokers, and smokers used relatively more superficial abdominal muscles than nonsmokers.

According to the study of Richardson, Hodges, Hides, the high activation of deep abdominal muscles increases trunk stability. But excessive activation of relatively superficial abdominal muscles leads to mechanical changes in the spine and increases the risk of low back pain. According to the results of present study, the high activity of relatively deep abdominal muscles in nonsmokers affects trunk stabilization, and the high activity of the relatively superficial abdominal muscles in smokers may increase the risk of low back pain and will cause functional changes in the musculoskeletal system. Moreover, if the high activity of the deep abdominal muscles during coughing is a general activation pattern of the abdominal muscles seen in nonsmokers, exercise to activate the deep abdominal muscles in smokers with a higher frequency of sputum discharge and coughing than nonsmokers would be helpful in alleviating their coughing and sputum discharge.

Table 1. Abdominal muscle activation of smokers and nonsmokers

| %MVIC | Smoker (n=15) | Nonsmoker (n=15) |
|-------|--------------|------------------|
| RA    | 6.87±2.68    | 5.67±0.70        |
| EO    | 7.67±1.12    | 10.07±1.29       |
| IO and TrA* | 11.13±0.99   | 19.07±2.17       |

*Statistically significant (p<0.05)
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