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Non-Task-Specific Training to the Latissimi Dorsi and Oblique Abdominal Muscles

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ABSTRACT

The latissimi dorsi and oblique abdominal muscles have many functions, one being compressor of the thoracic cage and abdominal wall. The purpose of this study was to investigate whether non-task-specific training to these muscles would increase their forced expiratory strength. Of 53 female college students, 16 performed 'push-ups', 15 expiratory muscle strengthening, and 14 trunk rotation for eight consecutive weeks. The participant's maximal positive expiratory pressure (P_{Emax}) was measured before, midway through, and immediately on termination of the training. The eight control students participated only in measurement of their P_{Emax}. The analysis using the Student's t-test revealed that PEmax within each group with exception of the control group increased significantly on completion of the training. However, comparison among the groups demonstrated that PEmax of only the latissimi dorsi group was significantly higher. Therefore, 'push-ups' to strengthen the latissimi dorsi may be a useful addition to a respiratory treatment regimen to further enhance bronchial hygiene techniques.

KEY WORDS

positive expiratory pressure, non-task-specific training, latissimi dorsi, oblique abdominal muscles, cardiopulmonary physiotherapy

INTRODUCTION

In cardiopulmonary physiotherapy practice, it is common to use such devices as PFLEX and the Threshold Inspiratory Muscle Trainer for ventilatory muscle training[1,2,3,4]. Recently, a Threshold Positive Expiratory Pressure (TPEP) device has been developed to strengthen the expiratory muscles[5]. It is well known that quick and forceful contraction of the expiratory muscles reduces the volume of the thoracic cavity, which assists in the forceful expiratory manoeuvre of coughing.

Latissimus dorsi (LD) and obliquus externus and internus abdominis are trunk muscles[6], and origins of the former are from the dorsal and lumbar vertebrae, sacrae midline, posterior iliac crest and the lower ribs. All of the LD's fibres unite in a common tendon on insertion into the humerus. The oblique abdominal muscles are situated antero-laterally over the abdomen and retain the abdominal viscera in position. When the thorax and pelvis are fixed, the active contraction of these muscles exercises a compressive force on the abdominal viscera. The LD and oblique abdominal muscles play, among other functions, an important role in thoracic cage compression when performing forced expiration and coughing. The research question of this study was: 'Would strengthening the latissimi dorsi by means of 'push-ups' and the oblique abdominal muscles by means of trunk rotation exercise yield a higher expiratory force?'

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METHODS

Participants

Fifty-three female college students, all non-smokers, participated in this study. The mean (SD; range) age of this convenience sample was 20.0 (0.9; 18-21) years old, mean (SD; range) height 159.1 (4.4; 150 to 169) cm, and mean (SD; range) body mass 50.4 (4.7; 41 to 60) kg, respectively. None of them had been engaged in any regular athletic training, nor had they experienced any cardiopulmonary dysfunction or musculoskeletal disorder of the thoracic cage and trunk. The participants were randomly assigned to four groups; 'push-ups' (n=16), TPEP (n=15), trunk rotation (n=14), and control (n=8) groups, respectively.

Measurement

The participant was given an explanation of the purpose and procedures for this experiment. The Vitalopower KH-101 (Chest M.I. Inc., Japan) was used for the measurement. The P_{Emax} was defined as the maximal positive pressure expressed in centimetre of water (cm H_2O) that could be measured at the mouth when participants performed a maximal static expiratory effort against an occluded airway, which is regarded as a measure of expiratory muscle strength[7]. In order to obtain baseline expiratory muscle strength, P_{Emax} measurement was conducted with the participant seated holding a mouthpiece and a nose clip in situ. P_{Emax} was measured at total lung capacity, but maximal expiratory effort lasting less than one second was discarded. This manoeuvre was repeated three times and the highest reading was taken as the participant's P_{Emax}. The participant was allowed an interval of one minute to elapse before each measurement. Also allowed was a small air leak in the circuit during the manoeuvre to prevent the facial muscles from producing significant pressures. The verbal command was provided by a pre-recorded cassette tape, so that it remained constant. The subject repeated the P_{Emax} measurement three times; one was just before commencement of training, the next four weeks after the commencement, and, finally, immediately after the completion of the eight-week period of training. The participants were prohibited from drinking coffee, or other caffeine containing beverages on test days.

Training

The participants trained their LD, expiratory muscles, and oblique abdominal muscles as follows: In order to strengthen the LD the participants performed 'push-ups' in long sitting. One set of exercises consisted of ten 'push-ups' and a complete training session was three sets of 'push-ups' with a one-minute interval between each set. This training was defined as non-task-specific training to the LD.

The participant performed expiratory muscle training in sitting using a TPEP device (HealthScan Products Inc., USA). A complete training session consisted of three sets of ten repetitions with one minute of rest between each set. Participants were instructed to breathe out against the expiratory threshold load with every breath. The threshold load of the training device was set at 30 % of the participant's baseline P_{Emax}, which is considered to be the minimal load required to significantly increase muscle strength. However, for some participants whose baseline value had over 67 cm H_2O, the threshold load was set at 20 cm H_2O which is the maximal threshold load built in the device. This training was defined as task-specific to the expiratory muscles.

For the trunk rotation group, the participants performed trunk rotation in crook-lying to strengthen the oblique muscles of the abdomen. They repeated three sets of ten trunk rotations to the right and three sets to the left. The order of the trunk rotation was reversed every day. This was also defined as non-task-specific training.

The verbal command and rhythm during the training session was also pre-recorded on a cassette tape. The time when training took place was arranged in such a way that participants performed at the same time every day from Mondays to Fridays for eight consecutive weeks. The participants in the control group participated only on three occasions for the P_{Emax} measurement.

Analysis

The paired t-test was used to compare the three P_{Emax} measurements within each group and the unpaired t-test to compare the data among the four groups. A probability value of 0.05 was set to determine statistical significance.

RESULTS

P_{Emax} for the 'push-ups' group increased gradually throughout the study period, and had, on average, 6.7 (85.5±23.1 vs. 92.2±19.2) cm H_2O higher by completion of the training, which was statistically significant. P_{Emax} for the TPEP group increased throughout the training period, and had, on average, a rise of 9.6 (79.1±16.3 vs. 88.7±16.8) cm H_2O by completion of the training, which was also statistically significant. However, most of this increase occurred during the latter four weeks.

P_{Emax} for the trunk rotation group also increased gradually, rising, on average, 14.7 (77.0±31.0 vs. 91.7±30.4) cm H_2O by completion of the training, which was again significant. The control group showed a slight, but non-significant, increase of P_{Emax} (71.5±17.6 vs. 74.7±18.5).

Although the participants within each experimental group gained a significant increase in P_{Emax}, when all of the four groups were compared to each other, only the 'push-ups' group demonstrated a significantly higher P_{Emax} (Figure). A combined analysis of the 'push-ups' and trunk rotation groups versus the control group also did not yield any statistical significance.

DISCUSSION

Two comments can be derived from these findings: First, it is considered that the LD plays an important role in transfer activities, especially, for paraplegics and bilateral lower limb amputees. These muscles are chiefly trained by means of 'push-ups'. They also act as a strong thoracic compressor due to their anatomical position. Thus, the fact that the 'push-ups' group achieved a significant increase in P_{Emax} demonstrates that non-task-specific training to LD may augment sputum expectoration techniques such as coughing and forced expiration technique. However, it will continue to remain common practice to use a threshold device for task-specific training to the expiratory muscles.

According to Gray's Anatomy, the external oblique muscles of the abdomen depress and compress the lower thorax, which aids expiration, if the pelvis and vertebral column are fixed[6]. However, in this study, P_{Emax} was measured in sitting, and so, the vertebral column could not be fixed completely. Because of this, maybe not enough expiratory power was generated during the measurement, resulting in a non-significant increase in the P_{Emax} for the trunk rotation group compared to the control group. Different approaches for the training methods may need further

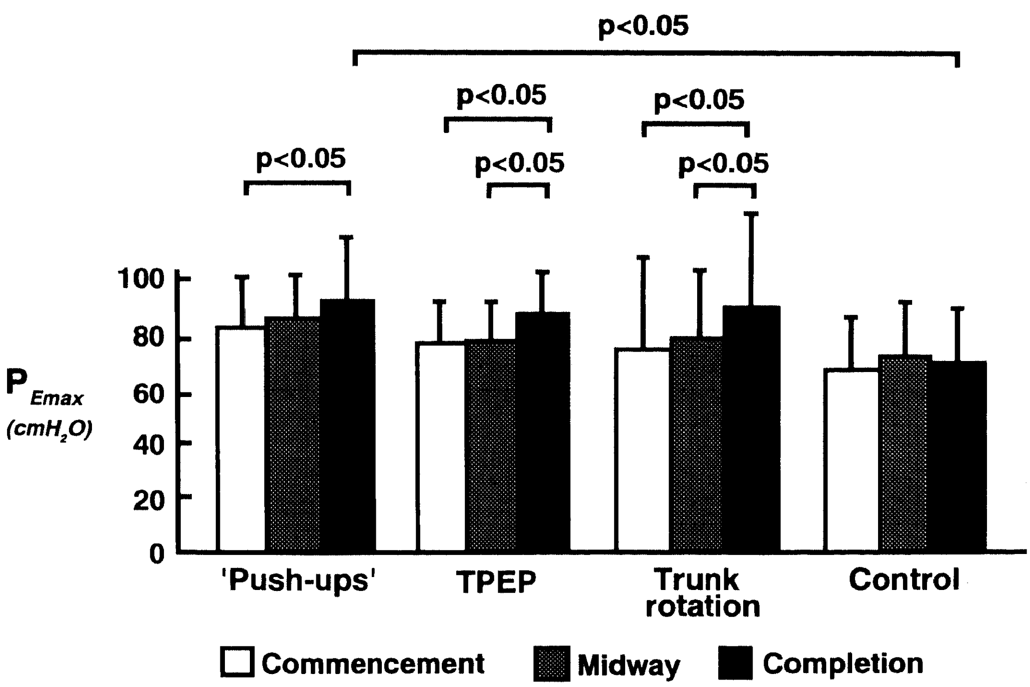

Figure. Mean P_{Emax} values of four groups. (TPEP: threshold positive expiratory pressure) investigation.

The second comment concerns the 'overload' principle which must be applied if one expects an increase in expiratory muscle strength just as in any other skeletal muscle training. It is a known fact that a load of 25 to 35 % of the maximal static respiratory pressure must be given to obtain a training effect. During training for this study the mean threshold load for the TPEP group ranged from 21.9 to 24.5 % of the baseline values. However, having achieved a significant increase in P_{Emax} within this group, the resulting threshold load seems to have been sufficient to increase expiratory muscle strength, when it was carried out for a relatively long period of time, although, in practice, client compliance may prove to be a potential problem when trying to sustain it. In Cahalin and his associates' study involving persons with advanced heart failure, they were successful in increasing inspiratory muscle strength with only 20 % of maximal inspiratory pressure[8]. This fact, in theory, can also be applied to the expiratory muscles. Another point to make on the second comment is that a significant increase in P_{Emax} within the TPEP group may have been brought about by the practice effect, because the positions and manoeuvres for the P_{Emax} measurement, and expiratory muscle training are almost the same, hence task-specific.

CONCLUSIONS

Based on the results of this study, 'push-ups' to strengthen the LD may be a useful addition to a respiratory treatment regimen to further enhance bronchial hygiene techniques. This study, however, was somewhat limited because young healthy participants were used for the experiment. These findings, therefore, may not be extrapolated directly to clients with chest pathologies. But, it is hoped that this study will be applied to such patients with chronic obstructive pulmonary disease and other conditions that require efficient bronchial hygiene.

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広背筋と腹斜筋の非動作特異的強化

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要　　旨

腹斜筋は咳嗽時や息む際に強力に活動するが，広背筋も強力な呼息に関わっている。広背筋を押上動作を通して強化し，また腹斜筋を体幹回旋動作を通して強化することにより，努力性呼息力が増すか否かを検証した。広背筋強化群（16名），閾圧式呼息筋訓練器を用いた動作特異的呼息筋強化群（15名），および腹斜筋強化群（14名）に分けた女子大学生に連続８週間のトレーニングを行わせた結果，各群の最高呼気圧は有意に増した。しかし群間比較においては，広背筋強化群の最高呼気圧のみが対照群（８名）のそれよりも有意に高かった。広背筋の非動作特異的強化は気管支浄化手段の一助になりうる。