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Original Article

Effects of lumbopelvic sling and abdominal drawing-in exercises on lung capacity in healthy adults

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Abstract. [Purpose] To examine the effects of lumbopelvic sling and abdominal drawing-in exercises on the lung capacities of healthy subjects. [Subjects and Methods] Twenty-nine healthy subjects with no orthopedic history of the back were recruited. Subjects were randomly assigned to a experimental group and control group. Subjects were allocated to one of two groups; an experimental group that underwent lumbopelvic sling and abdominal drawing-in exercises and a control group that underwent treadmill and abdominal drawing-in exercises. Lung capacities were evaluated 4 weeks after exercises. [Results] The experimental group showed significant increments in EV, ERV, IRV, VT vs. pre-intervention results, and the control group showed significant increments in the EVC and IRV. Significant intergroup differences were observed in terms of post-training gains in EVC, IRV, and VT. [Conclusion] Combined application of lumbopelvic sling and abdominal drawing-in exercises were found to have a positive effect on lung capacity.
Key words: Abdominal drawing in maneuver, Lung capacity, Sling exercise

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INTRODUCTION

Cardiorespiratory fitness (CRF) is a measure of the capacity of the cardiovascular system to transport oxygen and the ability of the muscles to use this oxygen. In addition, CRF reflects the ability of the circulatory, respiratory, and muscular systems to supply oxygen to skeletal muscles during sustained physical activity[1)], and thus, CRF is associated with health outcomes. Furthermore, accumulating evidence demonstrates CRF is independently associated with morbidity and mortality in the general population[2–4)]. Sling exercise is a new training method for athletes and orthopedic patients[5)]. Because of its convenience and practicality, sling exercise has become more and more common in rehabilitation clinics and fitness training centers[6)]. Recently, researchers have reported that lumbopelvic sling exercises are effective for strengthening respiratory muscles[7)], and Lukens et al.[8)] advised that these exercises effectively strengthen transverse abdominalis muscle, which is an important respiratory muscle. However, few studies have been performed on the clinical effects of combined lumbopelvic sling and respiratory muscle strengthening exercises. Therefore, in the present study, we studied the effects of combined lumbopelvic sling and respiratory muscle strengthening exercises on vital capacity.

SUBJECTS AND METHODS

This study was conducted on 29 healthy individuals without an orthopedic history after obtaining informed consent. All

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procedures were reviewed and approved by the Institutional Ethics Committee of Eulji University Hospital. The subjects were randomly assigned to an experimental group of 15 subjects or a control group of 14 subjects. Both the experimental group and the control group received ADIM (abdominal drawing-in maneuver) exercise for 20 minutes per session. Members of the experimental group also received a lumbopelvic sling exercise for 20 minutes per session, whereas control group members received 20 minutes of additional treadmill training. Exercises were performed 40 minutes per session once per day, five times per week, for four weeks, which is referred to as the intervention period.

The study selection criteria were as follows: 1) had not performed any trunk muscle-related exercise during the three months prior to selection; 2) no history of surgery in the waist region; and 3) the absence of lower back pain. In experimental and control groups average ages, heights, and weights were 20.93 ± 1.33, 20.64 ± 1.15 years, 173.45 ± 5.56, 170.69 ± 4.27 cm, and 64.05 ± 10.19, 60.11 ± 6.82 kg, respectively. The sling exercise group represented the high load exercise group. Sling exercises for the lumbopelvic region were performed using the Redcord Trainer (Redcord AS, Norway), which has been previously described by Stuge et al.[9)] Elastic ropes attached to a band supporting the pelvis were used to ease loads, help subjects maintain a neutral spine position at all times, and to eliminate exercise-associated pain. Exercise progression was achieved by gradually reducing the elasticity of the ropes or increasing distance (torque) to the distal band. Participants were tested for muscle weakness using the slings using a preset number of stabilizing exercises. When weakness, pain, fatigue or asymmetry was observed, this loading position served as a starting point for training and progression. The number of repetitions/sets was adjusted on an individual basis according to pain and fatigue. All training sessions were guided by a trained physical therapist. Examples of sling exercises with non-elastic ropes or firm ropes supporting the distal leg(s) and elastic ropes supporting the pelvis. The purpose of the elastic ropes was to assist subjects raise the pelvis to a neutral lumbar spine position. This position was then maintained for as long as possible. Load was progressively increased by provided less pelvic support increasing the elastic strengths of the pelvic ropes, increasing the lever arm distance of firm rope attachment points, increasing lower extremity movement range or removing distal support for one leg. Exercises were performed prone, supine, and side-lying.

ADIM was implemented while in a crook-lying position on a stable surface[10, 11)]. A pressure biofeedback apparatus (Stabilizer, Chattanooga Group Inc., USA) was placed below L5 to obtain visual feedback during ADIM. Subjects were instructed to slowly draw in the lower abdomen (below the navel) toward the floor, and not to move the upper abdomen or spine, to maintain the pelvis in the neutral position, and to maintain the pressure displayed by the pressure biofeedback apparatus in the range 40–70 mmHg during the procedure.

A breathing evaluation tool (Quark Spiro, COSMED sri, Italy) was used to measure respiratory competence and slow vital capacity was selected as a measurement variable. To measure, the subject's nose was blocked using a nose clamp and the subject was instructed to breathe normally through the mouth. For measurements, the subject was instructed to hold a breathing measuring instrument in his/her mouth after maximum inhalation and to breathe out slowly over up to 10 secs. Expiratory vital capacity (EVC), expiratory reserve volume (ERV), inspiratory reserve volume (IRV), expiratory minute ventilation (VE), respiratory frequency (RF), tidal volume (TV) were measured three times and average values were calculated. Intra-group comparisons of lung capacity before and after intervention were performed using the paired samples t-test, and intergroup comparisons of pre- to post-test differences in lung capacity were performed using the independent t-test. The statistical analysis was conducted using SPSS 20.0 (SPSS, Chicago, IL, USA), and statistical significance was accepted for p values<0.05.

RESULTS

Twenty-nine subjects (experimental group=15, control group=14) completed the experiment. The characteristics of the two groups (n=29) before and after intervention are shown in Table 1.

The experimental group showed significant increases in EV, ERV, IRV, and VT after intervention ($p<0.05$), and the control group showed significant increases in EVC and IRV ($p<0.05$). Significant intergroup differences in post-training gains were observed for EVC, IRV, and VT ($p<0.05$). The effect sizes of gains in the experimental and control groups were high for EVC, IRV, and VT (effect sizes 1.28, 0.82, and 0.96, respectively).

DISCUSSION

The present study was conducted to examine the effects of combined lumbopelvic sling and ADIM exercises on the respiratory competences of normal, healthy adult males. Significant intergroup post-intervention gains were observed for EVC, IRV, and VT. The respiration rate of an adult male at rest is 13–18 breaths/min, the amount of air inhaled per breath is 400–600 ml, and the amount of air inhaled per minute is 4–15 l. During exercise the amount of air inhaled is proportional to oxygen uptake and to the CO_2 yield of active muscles[12)]. Accessory muscles act during forced inhalation or extended active inhalation. Accessory muscles for exhalation are core muscles, such as, the rectus abdominis, the internal/external oblique, and the transverse abdominis, and when these muscles contract, pressure in the thoracic cage increases and air is forced out of the lungs[13)]. During inspiration, respiratory muscles expand the ribs, increase diaphragm movement, and draw air into the lungs, and during expiration, these muscles are relaxed and air is discharged[13)].

Table 1. Characteristics of the experimental and control groups pre- and post-intervention (values are presented as means ± standard deviations)

	EG (n=15)			CG (n=14)		
	Pre-test	Post-test	CWG	Pre-test	Post-test	CWG
EVC (ml)[a,b]	3.14 ± 0.84	4.54 ± 0.52	1.40 ± 0.96	3.02 ± 0.97	3.87 ± 0.51	0.85 ± 0.96
ERV (ml)	0.97 ± 0.51	1.63 ± 0.71	0.66 ± 0.96	0.88 ± 0.29	1.20 ± 0.51	0.31 ± 0.61
IRV (ml)[a,b]	0.89 ± 0.53	1.55 ± 0.46	0.66 ± 0.73	0.94 ± 0.40	1.23 ± 0.30	0.29 ± 0.40
VE (ml)	17.94 ± 8.71	22.41 ± 6.08	4.48 ± 8.88	15.37 ± 6.40	16.77 ± 7.65	1.39 ± 10.08
RF (ml)	17.74 ± 3.15	19.09 ± 2.90	1.35 ± 3.28	18.16 ± 5.45	18.81 ± 7.56	0.65 ± 4.67
VT (ml)[a,b]	1.10 ± 0.33	1.27 ± 0.23	0.16 ± 0.14	0.95 ± 0.41	0.97 ± 0.36	0.02 ± 0.60

EG: experimental group; CG: control group; CWG: intragroup changes
[a]Significant difference between gains in the two groups, $p<0.05$
[b]Effect size>0.70
EVC: expiratory vital capacity; ERV: expiratory reserve volume; IRV: inspiratory reserve volume; VE: expiratory minute ventilation; RF: respiratory frequency; VT: volume tidal

Exercise to improve respiratory competence are diverse. Recently, exercises based on the use of slings, intended to stabilize trunk muscles, have been used[14]. Sling exercises are performed using the subject body weight and antigravity, and have the advantages of requiring little space, being straightforward, and of enabling diverse exercises. As a result they are widely used to strengthen respiratory muscles[14]. In addition, unlike other exercise methods, sling exercises are effective for muscle strengthening because changes in body axis allow different movements[14]. Respiratory competence improvement by sling exercise is due to increases in the activities of core respiratory muscles that are required to maintain neutral posture during trunk movements caused by the external resistance applied by the sling. According to our results, the sling exercise activates the diaphragm which acts as an agonist for inspiration and accessory muscles for expiration to enhance respiratory competence. The effects of core exercises using slings include dynamic stabilization of the trunk and lumbar vertebrae, neutral control of the spine, and enhanced coordination of muscles that positively affect respiratory muscle strength[9]. The limitations of the present study include its small cohort, short duration, and lack of follow-up. Therefore, we suggest future studies be conducted to determine the long-term effects of combined lumbopelvic sling and ADIM exercise.

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