Research Article

Effect of ongoing isometric handgrip exercise on the inspiratory and expiratory reserve volumes

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Abstract

Background: Chronic diseases such as hypertension and diabetes have shown improvement in disease condition on isotonic exercises. But the same can cause deterioration in the health of patients with asthma, heart failure, and chronic obstructive pulmonary disease. Therefore, in such individuals, isometric exercise can be given a try. Isometric exercise is known to activate the autonomic nervous system, especially the parasympathetic fibers and thus has a bearing on the functioning of respiratory system. **Aims and Objectives:** This study was undertaken with a purpose to find acute change in respiratory reserve during handgrip exercise. **Materials and Methods:** 50 young apparently healthy volunteers between the ages of 18 to 35 years were enrolled for the study. Different spirometry volumes and capacities including inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) were recorded on MedSpiror (RMS, Chandigarh, India) at baseline and during sustained hand grip using a hand dynamometer. Statistical analysis was done using SPSS 17.0 on the data obtained. **Result:** This study showed that FVC was significantly reduced during handgrip exercise. FEV1, PEFR, FEF 25–75% and IRV decreased while FEV1/FVC and ERV increased but these changes were not significant statistically. **Conclusion:** The reserve capacity of the lung does not change significantly during isometric exercise.

KEY WORDS: handgrip exercise; FVC; FEV1; PEFR; FEF 25-75%; FEV1/FVC

Introduction

Muscle exercises are of two types—isotonic and isometric. Isotonic exercises such as walking, jogging, and running has proved beneficial in chronic diseases (e.g., hypertension, diabetes mellitus) and is widely advocated by clinicians and practiced by patients. Symptoms may get aggravated in some of the diseased conditions such as bronchial asthma (BA), chronic obstructive pulmonary disease (COPD), and congestive heart failure (CHF) due to exertion when involved in isotonic exercises.[1] In such cases, isometric exercises can be tried.

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Isometric exercise activates autonomic nervous system (ANS), predominantly the parasympathetic limb. Krzemiński et al.[2] showed that acute bout of static handgrip exercise increases adrenaline (A), nor-adrenaline (NA), and adreno-medullin (ADM) in healthy individuals. However, the increase in ventilatory response to isometric exercise could be attributed to the force of contraction during the exercise.[3]

Study by Mandanmohan et al.[4] revealed findings in opposite direction; yoga (bakasan, bhujangasan, and shalabhasan) increases the handgrip strength and handgrip endurance. Another aspect explored by Latorre-Román et al.[5] showed that handgrip strength was lower in children with asthma and handgrip strength test was able to discriminate between the presence and absence of asthma, and between intermittent asthma and moderate persistent asthma in children.

Handgrip strength also varied between obese and normal children and this resulted in significant decrease in pulmonary functions in obese children when compared to normal children when subjected to isometric exercise using handgrip dynamometer.[6]

Cortopassi et al.[7] showed that lower handgrip strength is associated with impaired heart function at rest and during exercise in COPD. Similar findings were also reported by a study done by Kim et al.[8] Since respiration is under involuntary control, we hypothesize that ANS modulation by isometric exercise may effect the respiratory function especially the forced respiratory parameters such as inspiratory reserve volume (IRV), expiratory reserve volume (ERV), vital capacity (VC), forced expiratory volume (FEV), and peak expiratory flow rate (PEFR). In diseased conditions, respiratory reserve is a key element which determines the subjective symptoms like dyspnea.

There is adequate literature on the effect of different types of exercise including yoga in the betterment of lung functions but there is scarcity of articles focusing on the influence of ongoing isometric exercise on the lung function reserve. Thus, this study was designed with an aim to determine the respiratory reserve during the isometric exercise. The objectives of the study were to measure the inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) during resting/baseline condition, to measure the inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) during handgrip exercise, to find out the difference between the resting condition and handgrip exercise, and to evaluate the effect of acute isometric exercise on other spirometric parameters.

Materials and Methods

This study was conducted in the Department of Physiology between April and August 2015, after obtaining approval from Institutional Review Board of our medical college. A total of 50 apparently healthy young volunteers in the age group of 18–35 years belonging to both genders were enrolled for the study after taking informed consent. Demographic and anthropometric parameters were documented. Subjects with history of bronchial asthma, chronic bronchitis, congenital heart diseases, rheumatic heart disease, and seizure disorders were excluded.

Methodology

Isometric exercise: Isometric exercise was performed by handgrip dynamometer. Subjects were explained about the procedure. Before the start of the recording, 10 min relaxation was given. Spirometry was performed in standing posture using MedSpiror (RMS Pvt. Ltd., Chandigarh, India) for baseline parameters. The procedure was repeated twice during which the subject gets acquainted with the setup and motivated to perform better. Best of the three readings of FVC, FEV1, PEFR, FEF25-75%, FEV1/FVC, IRV, and ERV was taken.

Then subjects were asked to press the handgrip dynamometer with maximum force with left hand. T_{max} was noted. Following this, subjects were asked to press the dynamometer at 30% of T_{max} for 3 min. After 1 min, still holding the dynamometer in left hand, they were asked to hold the spirometer transducer with right hand and perform the spirometry.

Statistical Analysis

The data obtained were subjected to paired Student's *t*-test and Pearson's correlation using SPSS 17.0. The *p*-value <0.05 were considered significant.

Result

The mean age of the participants was 21 ± 2.92 years. Table 1 shows the participants' demographic data and mean of spirometry values. Of the 50 subjects, 41 (82%) were males and 9 (18%) were females. None of the participants were smokers.

Table 2 shows that mean FVC, FEV1, PEFR, FEF 25–75%, and IRV decreased during handgrip exercise compared to baseline where as mean FEV1/FVC and ERV increased during isometric exercise. However, the changes noted were statistically not significant except for FVC which had significance level of 0.007.

Pearson's correlation statistics done to assess association of demographic and anthropometric measures with spirometric parameters showed that there was a significant

Table 1: Subjects' data

Characteristics		Value
Age (years)		21.00 ± 2.92
Gender	Male	41 (82.0%)
	Female	09 (18%)
Height (cm)		170.22 ± 6.48
Weight (kg)		65.98 ± 11.57
Body mass index (kg/m^2)		22.72 ± 3.30
Body surface area (m^2)		1.75 ± 0.17
Smoking status	Nonsmoker	50 (100%)
	Smoker	0 (0%)
Baseline FVC (L)		3.15 ± 0.63
Baseline FEV1 (L)		3.01 ± 0.62
Baseline PEFR (L/s)		7.73 ± 2.01
Baseline FEF25-75% (L/s)		4.23 ± 1.14
Baseline FEV1/FVC (%)		95.98 ± 7.90
Baseline ERV (L)		1.09 ± 0.64
Baseline IRV (L)		1.38 ± 0.79
During Hand Grip FVC (L)		3.03 ± 0.70
During Hand Grip FEV1 (L)		2.95 ± 0.62
During Hand Grip PEFR (L/s)		7.46 ± 1.86
During Hand Grip FEF25-75% (L/s)		4.09 ± 0.98
During Hand Grip FEV1/FVC (%)		97.60 ± 3.86
During Hand Grip ERV (L)		1.12 ± 0.73
During Hand Grip IRV (L)		1.19 ± 0.57

Continuous variables are presented as mean ± standard deviation. Categorical variables are presented as number (percentage).

Table 2: Changes during handgrip exercise – paired sample *t*-test

	Baseline	Handgrip	Mean difference	95% CI for mean difference		*t*	*df*	*p*	*r*	*p*
				Lower	Upper					
FVC (L)	3.15 ± 0.63	3.03 ± 0.70	0.12	0.03	0.20	2.83	49	0.01*	0.90	0.00*
FEV1 (L)	3.01 ± 0.62	2.95 ± 0.62	0.07	−0.03	0.17	1.33	49	0.19	0.83	0.00*
PEFR (L/s)	7.73 ± 2.01	7.46 ± 1.86	0.27	−0.05	0.60	1.69	49	0.09	0.83	0.00*
FEF25-75% (L/s)	4.23 ± 1.14	4.09 ± 0.98	0.14	−0.07	0.35	1.31	49	0.19	0.76	0.00*
FEV1/FVC (%)	95.98 ± 7.90	97.60 ± 3.86	−1.63	−3.76	0.50	−1.54	49	0.13	0.35	0.01*
ERV (L)	1.09 ± 0.64	1.12 ± 0.73	−0.03	−0.26	0.20	−0.29	49	0.78	0.32	0.03*
IRV (L)	1.38 ± 0.79	1.19 ± 0.57	0.18	−0.07	0.44	1.44	49	0.15	0.11	0.43

*Statistically significant

correlation of height with baseline FVC ($r = 0.664$, $p = 0.000$), FEV1 ($r = 0.642$, $p = 0.000$), PEFR ($r = 0.725$, $p = 0.000$), and FEF25–75% ($r = 0.368$, $p = 0.009$). There was no significant correlation between height and baseline FEV1/FVC, ERV, and IRV. During handgrip exercise, height had significant correlation with FVC ($r = 0.675$, $p = 0.000$), FEV1 ($r = 0.671$, $p = 0.000$), PEFR ($r = 0.619$, $p = 0.000$), ERV ($r = 0.335$, $p = 0.017$) whereas FEF 25–75%, FEV1/FVC, and IRV had no significant relation. Body surface area had positive significant correlation with most of the spirometry readings except FEV1/FVC which showed negative correlation. Age did not have any correlation with lung function parameters. Weight and body mass index correlated only with few spirometry parameters. Corresponding parameters during baseline and isometric exercise showed significant correlation.

Discussion

In this study we made an attempt to elucidate the influence of acute bout of isometric exercise on lung functions. The principle finding of our study is that the inspiratory and expiratory reserve volume did not alter significantly by handgrip exercise. We chose static handgrip exercise as it is believed to promptly activate the autonomic nervous system. This indicates that the respiratory performance is the result of coordinated modulation of autonomic nervous system by inputs from exercising muscle, joints, respiratory centers, and cardiovascular centers thereby preserving the respiratory reserve and hence only subtle changes are seen.

Krzemiński et al.[2] showed that acute bout of static handgrip exercise increases adrenomedullin (ADM) in healthy individuals and mild-heart failure patients. Incremental form of acute exercise done using a bicycle ergometer in young males did not show any significant changes in the respiratory parameters except for FVC and VC which were reduced during the postexercise recording.[9]

Yoga and breathing exercises involve isometric contraction which is responsible for increased strength of skeletal muscles and improvement of ventilatory functions.[10,11] Mandanmohan et al.[4] showed that yoga especially bakasan, bhujangasan, and shalabhasan for a period of 6 months increases the FEV1, PEFR, handgrip strength, and handgrip endurance. Practicing yoga and aerobics 1 h twice a week for 3 months can lead to significant improvement in most lung function variables except VO_{2max} in young females.[12] Ahmed et al.[13] showed that beneficial effects of yoga on lung function is evident only after 2 months of regular practice as against the findings of Parikh et al.[14] whose study showed that 4 weeks of yoga training can cause significant increase in lung function parameters. Slow breathing, as happens during isometric exercise, has shown to improve functioning of autonomic system and thereby increase the activity of parasympathetic nervous system.[15]

Zayneev et al.[16] attempted to study the reaction of respiratory system to dosed isometric load in 9 year boys. Their study concluded that in such young children, dosed isometric load caused a decrease in lung function tests and in inspiratory and expiratory reserve volumes. But we did not get significant change in our study. The probable reason for their findings could be due to age of participants as the pediatric subjects lack the degree of motivation as in adults in performing effort-dependent maneuvers.

Our study focused on elucidating respiratory changes during acute bout of isometric (sustained handgrip) exercise which is the novelty of this study. However, there is one limitation to this study—only the upper limb and pectoral muscles were contracting during the procedure where in the effect on the respiratory parameters may not be as profound as contractions of many group of muscles seen in isotonic exercises such as walking and jogging.

Conclusion

To conclude, the reserve capacity of the lung does not change significantly during isometric exercise. Hence, it can be tried alone or in conjunction with isotonic exercises in persons suffering from cardiorespiratory disorders.

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