

**Original article:**

**EFFECT OF INTERCOSTAL STRETCH ON PULMONARY FUNCTION PARAMETERS AMONG HEALTHY MALES**

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**ABSTRACT**

The use of manual stretching procedures has become more prevalent in cardiorespiratory physiotherapy to improve pulmonary functions. However, limited evidence exists regarding evaluation of their effectiveness. The study aimed to determine the impact of Intercostal (IC) stretch in improving the dynamic pulmonary function parameters (Forced Expiratory Volume in the first second (FEV1), Forced Vital Capacity (FVC) and FEV1/FVC % and respiratory rate among healthy adults. Thirty healthy male subjects were recruited based on inclusion and exclusion criteria. Subjects were assigned to the experimental group and the control group through random sampling method. In the experimental group, subjects underwent IC stretch for ten breaths on the inspiratory phase of the respiratory cycle with breathing control exercises in semi recumbent position, while in the control group, breathing control exercises alone were performed in the semi recumbent position. The results of the study showed, FEV1/FVC % in the experimental group significantly improved with  $P=0.017$  ( $p<0.05$ ) than the control group, which means IC stretch increased lung volume and lead to improved lung function. This study suggested the IC stretching with breathing control may be more effective in improving dynamic lung parameters especially FEV1/FVC % than breathing control alone.

**Keywords:** Intercostal muscles, spirometry, vital capacity, breathing exercises

**INTRODUCTION**

Intercostal (IC) muscles are diverse and widely spread throughout the rib cage. These muscles are morphologically and functionally skeletal muscles, and it helps in

upward and outward movement of the ribs which results in increase in antero-posterior diameter of the thoracic cavity (De Troyer et al., 2005). The IC muscles help both in inspiration and forced expiration. Even though these muscles engage in respiration,

their activities are fewer during active contraction among normal healthy adults (Hirai et al., 1996). Neglect of skeletal muscle from a low level of physical activity is also a factor that may have detraining effect on muscle mass. This will have an impact on the oxidative capacity of the skeletal muscles and it will reduce the proportion of muscle fibers from type I to type II (Gosker et al., 2000). Hence, it can be hypothesized intercostal muscles which aids in the mechanical aspects of breathing may undergo atrophy when there is a poor physical activity. Therefore, this could have an impact on chest wall mobility and expansion in turn to ventilation on normal healthy adults.

Various research studies demonstrated that IC stretching improved expired tidal volume, decreased the level of dyspnea level and increased chest expansion clinically which results in better gaseous exchange in human subjects (Leelarungrayub et al., 2009; Bethune, 1975). IC stretch is performed actively by thoracic mobility exercises. Passively IC stretch can be performed by thoracic rotation, midsternum rotation, lateral thoracic stretching, through thoracic mobility exercises as well as through manual stretching of IC spaces (Leelarungrayub et al., 2009). The external IC muscles which are helpful during inspiration showed a higher discharge activity during forcible inhalation. Similarly, a stretch of 15 micrometers applied to IC spaces showed an increase in muscle activity in cats (Bolser et al., 1987). The increase in muscle activity of the IC muscles could lead to increase in lung volume and capacities. According to Puckree et al. (2002), IC stretching is effective in improving breathing pattern and respiratory muscle activity among healthy conscious adults. However; none of the research studies examined the effect of IC stretching on dynamic pulmonary function parameters among healthy subjects. Morphologically intercostal muscles displayed a variation in fiber size and atrophy among obstructive lung disease subjects (Campbell et al., 1980). Hence, a change in pulmonary function parameters while performing IC stretching might benefit to a particular pop-

ulation where respiratory compromise has been demonstrated due to poor IC muscle function. Therefore, the main purpose of the study was to observe the effect of IC stretching on pulmonary function parameters.

## MATERIALS AND METHODS

A sample size of thirty four was estimated initially with 5 % significance level and 80 % power by G\*Power 3 software (Faul et al., 2007). A total of four subjects, two from either group had been excluded from this study as they did not meet normal spirometry values due to inadequate effort, based on American Thoracic Society (ATS) /European Respiratory society (ERS) task force (Miller et al., 2005a, b; Pellegrino et al., 2005). Subjects were blinded, assigned based on table of random numbers and they were allocated to the experimental group if they received an odd number, while subjects who received an even number were assigned to the control group. All subjects were adults aged between 19 to 24 years old, with a mean age 21.73 years. Subjects were free from chronic diseases (WHO, 2005) and those with a history of rheumatologic disorders, smoking excluded from the study. Ethical approval for the study was obtained from institutional review and ethical board of University Teknologi MARA, Malaysia and informed consent was obtained from the subjects before the study.

### *Respiratory rate*

Before participation, all subjects underwent resting respiratory rate measurement. Initially the study subjects were requested to lie on a semi recumbent position and readings taken after 3 minutes of resting using auscultation methods. The method adopted in this study to measure respiratory rate was reliable according to a protocol described earlier (Edmonds et al., 2002).

### *Pulmonary function test*

The ventilator parameters such as forced expiratory volume in 1<sup>st</sup> second (FEV1), forced vital capacity (FVC) and

forced expiratory volume in first second percentage (FEV1%), were measured by pulmonary function test. A pulmonary function test was carried out by using the handheld spirometer (Pony Fx Cosmed, Italy) to estimate the dynamic lung function parameters. Participant's details were taken before pulmonary function testing such as age; height and weight using SECA weight and height scale (Vogel & Halke, Hamburg, Germany). Then, the variables were keyed into the Pony Fx Cosmed, Italy, spirometer (Ngai et al., 2009).

According to the (ATS)/(ERS) task force, spirometry training and testing were performed to ensure quality (Miller et al., 2005a, b). Testing was carried out in standing position and rest interspersed between each of the three tests. A chair was placed behind the participant, so that they could be quickly and easily moved into a sitting position if they feel any discomfort during the manoeuvre. The participants were requested to perform at least three trails and the best of the three values for the manoeuvre such as slow vital capacity and forced vital capacity was taken by the same physiotherapist as suggested by ATS/ERS task force (Miller et al., 2005a, b). The spirometry test was preceded with IC stretch.

### ***IC stretch and breathing control***

For the experimental group, initially a stretch was applied by the same physiotherapist on the left-side midway between the midaxillary line and a line through the nipple in the downward direction of the third IC space. The IC stretch was applied by the physiotherapist manually with the help of index finger over the third IC spaces in a caudad-cephalad direction to the upper borders of the fourth rib (Puckree et al., 2002). Enough care was paid to avoid compression of the chest wall.

Breathing control exercises were performed followed by IC stretching. This was performed in a comfortable semi recumbent position with a pillow under both knees. Participants were encouraged to place their hands over the upper abdomen. As the subject breathed in, the hands were placed over

the epigastric region to feel the rise; as they breathed out, the hand sank (Jennifer and Pryor, 2008).

Fifteen subjects from the experimental group received IC stretch with breathing control exercises where as other fifteen subjects received breathing control exercises alone in the semi recumbent position. Immediately, following intervention, the respiratory rates recorded and pulmonary function test were performed using spirometry to evaluate the effect of intervention in both groups. Subjects underwent three IC stretch and breathing control exercises with a time gap of 2-3 minutes for the experimental group. Each stretch was employed for ten breaths throughout the inspiratory phase of the respiratory cycle. For the control group they underwent breathing control exercises alone. A total of 15 minutes sessions lasted for both groups.

### ***Data analysis***

All analyzes were performed with SPSS version 17.0 software. The normality of the data was assessed using Kolmogorov-Smirnov. Wilcoxon signed rank test was used to determine the effect of IC stretch in experimental and control groups. Also, Mann-Whitney test, performed to find out if differences existed between the experimental and control groups in each parameter. The level of statistical significance was set at  $P < 0.05$ .

## **RESULTS**

The characteristics of the study subjects were as follows: age =  $21.3 \pm 1.72$  years, height =  $1.69 \pm 0.05$  centimeters, weight =  $65.63 \pm 0.46$  kilograms and BMI =  $23.14 \pm 3.88$  kg/ m<sup>2</sup> (Table 1). The baseline characteristics, showed there was no significant difference in the experimental and control groups before starting the protocol in FEV1, FVC and FEV1% ( $P = < 0.361$ ,  $P = < 0.819$  and  $P = < 0.547$ ) and the respiratory rate ( $P < .900$ ) respectively (Table 2).

**Table 1:** Physical characteristics of the study subjects

	N	Minimum	Maximum	Mean	Std. Deviation
Age	30	19 <sup>a</sup>	24 <sup>a</sup>	21.73	1.721
Height	30	1.59 <sup>b</sup>	1.79 <sup>b</sup>	1.6853	.04819
Weight	30	53 <sup>c</sup>	104 <sup>c</sup>	65.63	11.038
BMI	30	18.9000	40.0000	23.146667	3.8837179
Valid N (listwise)	30				

<sup>a</sup> Indicates age in years

<sup>b</sup> Indicates height in centimetres

<sup>c</sup> Indicates weight in kilogram

**Table 2:** Baseline characteristics of respiratory rate and ventilatory parameters

	Pre RR <sup>a</sup>	Pre FEV1 <sup>b</sup>	Pre FVC <sup>c</sup>	Pre FEV1% <sup>d</sup>
Mann-Whitney U	109.500	90.500	107.000	98.000
Wilcoxon W	229.500	210.500	227.000	218.000
Z	-.126	-.914	-.228	-.603
Asymp. Sig. (2-tailed)	.900	.361	.819	.547
Exact Sig. [2*(1-tailed Sig.)]	.902	.367	.838 <sup>a</sup>	.567

<sup>a</sup> RR indicates respiratory rate

<sup>b</sup> FEV1 indicates forced expiratory volume in 1<sup>st</sup> second

<sup>c</sup> FVC indicates forced vital capacity

<sup>d</sup> FEV1% indicates ratio of a and b

The comparison of pre and post test values of ventilatory parameters in experimental groups results showed there were significant differences in FEV1% ( $P < 0.03$ ) compared to control groups ( $P < 0.507$ ). However, there were no significant differences in FEV1 and FVC are shown in Table 3. This showed that ICs stretch showed improvement in FEV1% in the experimental groups.

The comparison of pre and post test values of respiratory rate showed significant difference between pre and post test values in the experimental group than con-

trol group ( $P < 0.003$ ;  $P < 0.042$ ) respectively given to the respondents in Table 4. This showed that ICs stretch showed some effect in reducing the respiratory rate.

The comparison of post intervention respiratory rate and ventilatory parameters between the group results showed there were significant difference between the groups in FEV1% alone ( $P < 0.017$ ). However, there were no significant differences among other parameters (Table 5). This depicted that there were changes in FEV1% alone when an IC stretch performed with breathing control exercises.

**Table 3:** Comparison of pre and post ventilatory parameters among experimental and control groups

	Post1 - Pre1 FEV1 <sup>a</sup>	Post1 - Pre1 FVC <sup>b</sup>	Post1 - Pre1 FEV1% <sup>c</sup>	Post2 - Pre2 FEV1 <sup>a</sup>	Post2 - Pre2 FVC <sup>b</sup>	Post 2 - Pre2 FEV1% <sup>c</sup>
Z	-.778 <sup>a</sup>	-1.387	-2.995	-.787	.000	-.663
Asymp. Sig. (2-tailed)	.436	.166	.003 <sup>d</sup>	.431	1.000	.507

<sup>a</sup> FEV1 indicates forced expiratory volume in 1<sup>st</sup> second

<sup>b</sup> FVC indicates forced vital capacity

<sup>c</sup> Ratio of a and b

<sup>d</sup> Indicates significant difference found in experimental groups

**Table 4:** Comparison of pre and post respiratory rate among experimental and control groups

	Post1 RR <sup>a</sup> - Pre1 RR <sup>a</sup>	Post2 RR <sup>a</sup> - Pre2 RR <sup>a</sup>
Z	-3.002	-2.031
Asymp. Sig. (2-tailed)	.003 <sup>b</sup>	.042

<sup>a</sup> RR indicates respiratory rate

<sup>b</sup> Indicates significant difference found in experimental group

**Table 5:** Comparison of respiratory rate and ventilatory parameters between the groups

	Pre RR <sup>a</sup>	Pre FEV1 <sup>b</sup>	Pre FVC <sup>c</sup>	Pre FEV1% <sup>d</sup>	Post RR <sup>a</sup>	Post FEV1 <sup>b</sup>	Post FVC <sup>c</sup>	Post FEV1% <sup>d</sup>
Mann-Whitney U	109.50	90.50	107.00	98.00	103.50	98.50	112.00	55.00
Wilcoxon W	229.50	210.50	227.00	218.00	223.50	218.50	232.00	175.0
Z	-.126	-.914	-.228	-.603	-.376	-.581	-.021	-2.38
Asymp. Sig. (2-tailed)	.900	.361	.819	.547	.707	.561	.983	.017
Exact Sig. [2*(1-tailed Sig.)]	.902	.367	.838	.567	.713	.567	1.000	.016 <sup>e</sup>

<sup>a</sup> RR indicates respiratory rate

<sup>b</sup> FEV1 indicates forced expiratory volume in 1<sup>st</sup> second

<sup>c</sup> FVC indicates forced vital capacity

<sup>d</sup> FEV1% indicates ratio of a and b

<sup>e</sup> Indicates significant differences found between the groups

## DISCUSSION

The findings of this study showed there was improvement in dynamic ventilatory parameter (FEV1/FVC%) among healthy conscious adults who had IC stretch with breathing control exercises compared to those with breathing control exercise alone. Clinically there were changes in FEV1 and FVC on certain subjects, despite no statistical changes in FEV1 and FVC.

The results of the present study is similar to a previous study which reported there was an effect on static ventilatory parameters (Puckree et al., 2002). The present study is in accordance with an earlier study in which IC stretch was given as one of the sets of unsupported arm exercises (Mohan et al., 2010). The IC may enhance the chest wall elevation and thus increase expansion to improve intra-thoracic lung volume which contributes to improvement in flow rate percentage. This may contribute to the increase in ventilatory capacity such as tidal volume, minute ventilation and oxygen status (Chang et al., 2002).

The changes in ventilatory parameters may be due to the firing discharge of the muscle spindle during a passive stretch phase (Hirai et al., 1996). IC stretching may have activated the stretch receptors in the chest wall, thereby distending the thorax which could be neurologically linked to medulla with efferent nerve cells.

It could also be argued that this altered ventilatory function may have resulted because of reflexive activation of the diaphragm by the ICs afferents that innervate its margins (Jennifer and Pryor, 2008). This neurophysiological facilitatory stimuli may account for more normal respiratory patterns among unconscious subjects (Jennifer and Pryor, 2008), but the present study was carried out to discover the effect on IC stretch among healthy adults.

Puckree et al. (2002) studied with the effect of IC stretch on third and the eighth IC space in which they proved there was decrease in breathing frequency when a stretch performed on third and eighth IC spaces. This study did not have statistically

significant values between the groups on respiratory rate. However, the rate of respiration lessened only in the experimental group, which showed there were impacts on respiratory rate also when an IC stretch was performed.

Although there is a lack of evidence that supports the use of this technique, the results showed improvements in dynamic ventilatory parameters (FEV1%). A previous study reported that localized stretch in the third and eighth IC space showed a deeper breathing pattern, greater activities on parasternal ICs, electromyographic activities which resulted in an increase in tidal volume and a decrease in breathing frequency among healthy subjects (Puckree et al., 2002). In addition, Threlkeld (1992) reported that applying manual techniques such as IC stretch may produce a suitable amount of plastic deformation of connective tissue to enhance mobility at joints. Therefore, the results of this study provide a preliminary evidence whereby IC stretch was an effective treatment parameter. Hence, future studies on a larger sample size may corroborate the findings in detail.

A possible limitation of our study was quantification of stretch pressure was not performed and it's uncertain how far these stretch receptors stimulated to evoke response. The respiratory rate measurement which was used in our study did not provide a sensitive measure of change in the group (Evans et al., 2001). Therefore, future design of stretching protocol and its measured quantities in cardiorespiratory physiotherapy may be considered in order to promote ventilation.

### CONCLUSION

The present study showed there were increases in dynamic ventilatory parameters only in FEV1% among healthy conscious subjects who underwent IC stretch compared to the subjects who underwent breathing control exercises alone for ten breaths. This change in ventilator parameters, enhanced lung volume when a stretch is performed. It can be necessitated that this IC

stretch method might be an alternative for subjects incapable of engaging in active rehabilitation exercises. This study provides baseline information for the changes in pulmonary function parameters after an IC stretch which could be useful in directing future studies on patient populations. Thus, we speculate that this mode of stretch might help in promoting ventilation when it can be applied to subjects with pulmonary disease.

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