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Diaphragmatic thickness responses in relation to inspiratory and expiratory muscles training in adults

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All muscles require training- including ones for breathing. In this randomized, controlled study, Thirty seven adults participated were included. Diaphragmatic excursion, inspiratory and expiratory thickness were assessed by ultrasonography machine and Borg scale for measuring perceived exertion. All of the parameters were evaluated before and after 6 weeks from the beginning of the training. Nineteen cases underwent power lung device training, while routine chest physiotherapy including (diaphragmatic breathing, belt breathing, and localized breathing) was applied in the remaining eighteen cases. There were no significant change in inspiratory thickness in both groups at the end of the study; also there were significant change in expiratory thickness in the study group relative to the control group. Regarding study group diaphragmatic excursion showed no significant difference after the training in both groups; also there were significant differences between pre- and post-Borg scale within group A and group B but with no significant differences in it between both groups. It was concluded that breathing exercises improves diaphragmatic thickness more than power lung device.

Keywords: Power lung device / breathing exercises / respiratory muscles.

INTRODUCTION

Respiratory muscles, including the diaphragm, are extremely skeleton-related muscles and share functional features with limb muscles, therefore, they should respond to training in the same way like limb muscles respond when the proper body structure related load is applied (Enright et al.,2006).

Respiratory muscle training (RMT) may improve exercise ability. Because, it delays or prevents the respiratory muscles fatigue(RMF) and its effect on blood flow redistribution more than that, and causes improvement in the blood flow need for breathing and respiratory muscles along with the exercise (Gigliotti et al.,2006).

Powerlung is a hand-held, spring-loaded device designed to strengthen respiratory muscles and prepared with changeable resistance, controls dials to set levels of resistance for both breathing in and exhalation. The device is set to a challenging level of resistance, which is prefect according to (Enright et al., 2006), is 60-80% of the person's highest possible inspiratory and expiratory pressure abilities.

The Power lung is a threshold loading device consisting of a stiff plastic tube housing two rubber plungers, each held in place a spring. To produce significant airflow the subject must create respiratory pressure (PTH), causing the spring to press and the plunger to lift off its port. Although the Power lung can place a resistance on both the inspiratory and expiratory muscles,the expiratory port can be sealed to manage and do a more clearly stated examination of inspiratory muscles (Watsford, and Murphy.2008).

Normal values of diaphragmatic thickness in healthy subjects at functional residual capacity (FRC) range from 1.8 to 3 mm. the diaphragmatic thickness is assessed by M mode ultrasonography. The assessment of the thickness is done during quiet breathing and during a maximal inspiratory and expiratory effort (Chiumello et al., 2016).

The original Borg scale or rating of perceived exertion (RPE) is a scale from 6 to 20 that allows clients to answer the question " How hard am I working?" numbers on the scale correspond to heart rate when they are multiplied by 10. So a rating of 12 (between "fairly light" and "somewhat hard") is roughly equivalent to a heart rate of 120 (12×10). A rating of 12-16 ("somewhat hard "to "hard") on the original Borg scale is appropriate for apparently healthy people who do not have cardiovascular disease but who may have cardiovascular risk factors. The revised or modified Borg scale ranges from 0 to 10 and may be easier for people to use quantifying their feelings of exertion, in this scale 10 corresponds with "very, very strong", while 3 is "moderate" (Summerfield,2015).

So, the objective of the current study was to determine the summative effect of strength training of both inspiratory and expiratory muscles on diaphragmatic thickness and excursion, which express the diaphragmatic power and strength in adults.

MATERIALS AND METHODS

Subjects and study design:

This randomized and controlled study, which aimed to compare the results of different physiotherapy techniques on respiratory muscles strength , was conducted in the Faculty of physical therapy, Cairo University, Cairo, the study was done between January and December 2017.Thirty seven (18 men-19 women) subjects participated in this study; they were recruited from Faculty of physical therapy, Cairo University, there ages ranged from 20-30 years old, with BMI ranged from (18-25 Kg/m²), All subjects were free from cardiovascular, pulmonary and neurological disease. They were assigned randomly into two groups A and B (study and control): Group A (Study Group) nineteen subject (ten women and nine men) were received training by the powerlung device (trainer) for six successive weeks, 3 times per week, 10-15 minutes for each session. Group B (Controlled Group) eighteen subjects (nine women- nine men) were received routine chest physiotherapy including (diaphragmatic breathing, belt breathing, and localized breathing) for six successive weeks, 3 times per week, 15**:**20 minutes for each session. The study was approved by ethical committee of Faculty of Physical Therapy, Cairo University, approval number; P.T.REC/012/001226.

Diaphragmatic sonography assessment:

It was for measuring diaphragmatic thickness and displacement. The subject was putted in trendelenberg position. The diaphragm was scanned by ultrasonic examination in both maximal inspiration and maximal expiration via anterior abdominal wall under costal margin. On the right side of the diaphragm two sweeps of the transducer were done, one in maximal inspiration and the other in maximal expiration while multiple sweeps were done on the left side as the diaphragmatic excursion.

Borg scale assessment:

The subjects were asked to numbered on the scale correspond their feelings of exertion.

Powerlung device Session:

For Group A (Study Group):

Adjustment was done for the device resistance to the prescribed setting according to performance gains, based on manufacturer guidelines. The subjects sat comfortably and upright while holding the mouthpiece tightly between the lips. They were asked to take in breath that larger than normal but not to fill the lunges completely. The session was consisted of 3 sets of 10 repetitions each set toke approximately 2 min duration, there was 2 min rest involving normal quit breathing between sets. The nose of the subject was closed by nasal clips when performing RMST (respiratory muscle strength training) exercises. The subjects were asked to breathe in through power lung device for 3 seconds, fill lungs as completely as possible in this time, hold for 2 seconds and Breathe out through power lung device for 3 seconds. Each session was about 10-15 min.

Breathing exercises Session:

For Group B: (Control Group): includes:

Each session consisted of Diaphragmatic breathing, Localized breathing and Belt exercise which was done as traditional steps , each session was about 15-20 min.

Follow up procedures

The follow up procedures included Diaphragmatic sonography assessments for measuring

diaphragmatic excursion, inspiratory thickness and borg scale assessment pre and post training for both groups

Statistical analysis

The statistical analysis was conducted by using statistical SPSS Package program version 20 for Windows (SPSS, Inc., Chicago, IL).

Descriptive statistics including the mean and standard deviation for age, weight, height, BMI, diaphragmatic excursion, ins. thickness, and exs. Thickness variables

Paired t-test to compare between pre and post-treatment within groups A and B for diaphragmatic excursion, ins. thickness, and exs. Thickness variables.

Unpaired (Independent) t-test to compare between groups A and B with pre- and post-treatment for age, weight, height, BMI, diaphragmatic excursion, ins. thickness, and exs. Thickness variables.

Wilcoxon test to compare between pre and post-treatment within groups A and B for Borg scale variable.

Mann-Whitney test to compare between groups A and B with pre- and post-treatment for Borg scale variable.

All statistical analyses were significant at 0.05 level of probability ($P \leq 0.05$).

RESULTS

Demographic and other baseline data in both groups: Table (1) represents a summary of subjects' demographic data and clinical characteristics at the beginning of the study as age, weight, height and body mass index (BMI) as shown in tables (1).

2-Ultrasonographic measures: It was observed that there were no statistical significant differences in diaphragmatic excursion after 18 sessions of training with power lung device current group comparing it to the breathing exercise current group ($p>0.05$), and There were no significant differences between pre- and post-inspiratory thickness within group A and group B ($P>0.05$), while there were significant differences between pre- and post-expiratory thickness within group A ($P=0.633$; $P>0.05$) and no significant differences between pre- and post-expiratory Thickness within group B, while, there was significant difference ($P=0.018$; $P<0.05$) in post-expiratory thickness between groups A and B as shown in tables (2 ,3 and4) and demonstrated in figures (1 ,2 and 3).

Table (1): Comparison of physical characteristics means values between groups A and B.

Items	Age (year)	Weight (kg)	Height (cm)	BMI (kg/m^2)
Group A	20.95 ±0.270	65.68 ±2.214	168.42 ±1.815	22.68 ±0.530
Group B	23.17 ±0.901	64.28 ±2.291	168.00 ±1.736	22.28 ±0.535
t-value	0.414	0.442	0.167	0.540
P-value	0.210	0.662	0.868	0.593
Significance	NS	NS	NS	NS

SE: standard error P-value: probability value NS: non-significant.

Table (2): Comparison between mean values of pre- and post-diaphragmatic excursion within each group and between groups .

	Diaphragmatic excursion					
	Group A		Group B		Post- training between groups	
	Pre-training	Post- training	Pre- training	Post- training	Group A	Group B
Mean ±SE	67.74 ±3.718	66.79 ±2.373	69.72 ±3.372	67.61 ±3.134	66.79±2.373	67.61±3.134
Mean difference	0.95-		2.11-		0.82	
t-value	0.234		0.863		0.210	
P-value	0.817		0.400		0.835	
% of change	1.40%↓		3.03%↓		----	
Significance	NS		NS		NS	

SE: standard error %: percentage P-value: probability S: significant NS: non-significant.

Table (3): Comparison between mean values of pre- and post- Inspiratory thickness within each group and between groups.

	Ins. Thickness					
	Group A		Group B		Post- training between groups	
	Pre- training	Post- training	Pre- training	Post- training	Group A	Group B
Mean ±SD	3.04 ±0.72	2.94 ±0.86	3.38 ±0.75	3.55 ±0.84	2.94 ±0.86	3.55 ±0.84
Mean difference	0.10-		0.17		0.61	
t-value	0.485		0.964		2.148	
P-value	0.633		0.394		0.039	
% of change	3.29% ↓		5.03% ↑		----	
Significance	NS		NS		S	

SD: standard deviation %: percentage P-value: probability S: significant NS: non-significant.

Table (4): Comparison between mean values of pre- and post-Exs. Thickness within each group and between groups.

	Exs. Thickness					
	Group A		Group B		Post- training between groups	
	Pre- training	Post- training	Pre- training	Post- training	Group A	Group B
Mean ±SD	1.67 ±0.43	1.36 ±0.34	1.69 ±0.42	1.71 ±0.51	1.36 ±0.34	1.71 ±0.51
Mean difference	0.31		0.02		0.35	
t-value	2.994		0.238		2.491	
P-value	0.008		0.841		0.018	
% of change	18.56% ↓		↑ 1.18%		-----	
Significance	S		NS		S	

SD: standard deviation %: percentage P-value: probability S: significant NS: non-significant.

Table (5): Comparison between mean values of pre- and post-Borg scale within each group and between groups.

	Borg scale					
	Group A		Group B		Post- training between groups	
	Pre- training	Post- training	Pre- training	Post- training	Group A	Group B
Mean ±SD	12.58 ±1.12	15.21 ±0.97	12.89 ±1.07	15.06 ±1.25	15.21 ±0.97	15.06 ±1.25
Mean difference	2.63		2.17		0.15	
t-value	12.815		11.697		0.420	
P-value	0.0001		0.0001		0.677	
% of change	20.91%		16.84%		------	
Significance	S		S		NS	

SD: standard deviation %: percentage P-value: probability S: significant NS: non-significant.

Figure (1):Show mean values of pre- and post-diaphragmatic excursion between both groups.

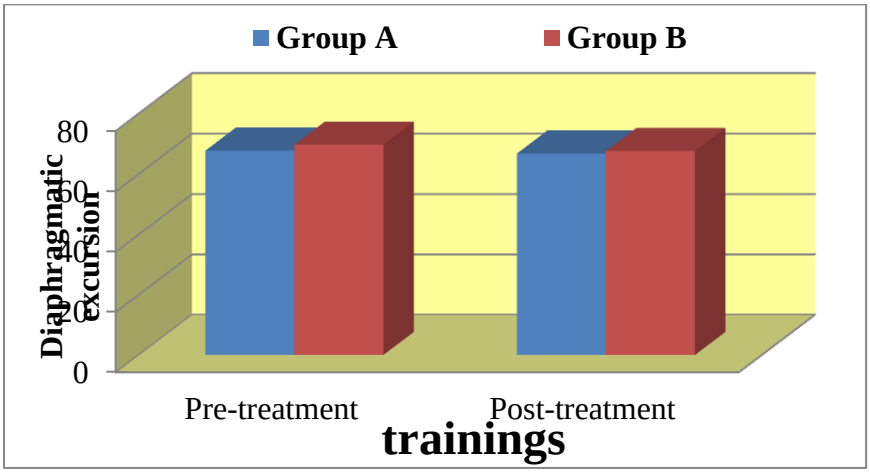


Figure (2):Show mean values of pre- and post-Ins. thickness between both groups

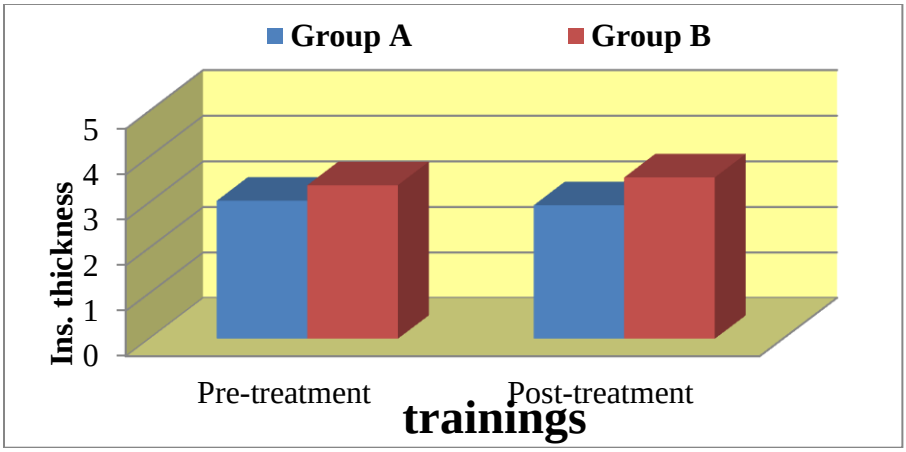


Figure (3):Show mean values of pre- and post-Exs. thickness between both groups.

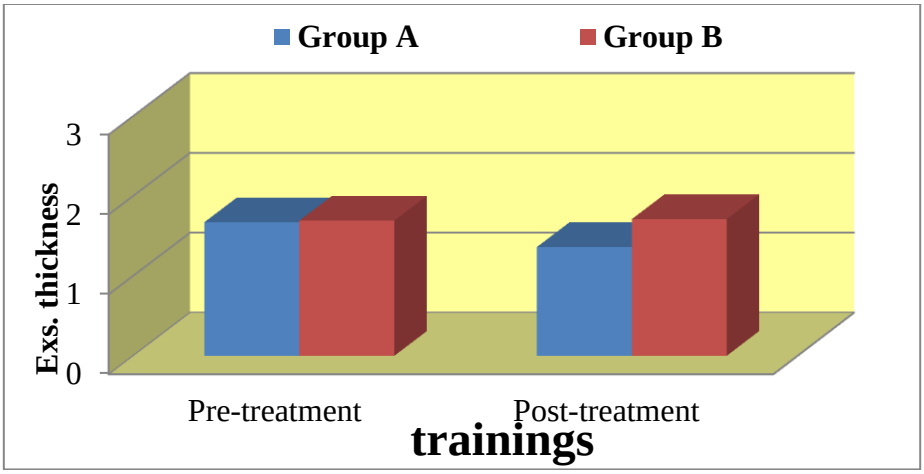
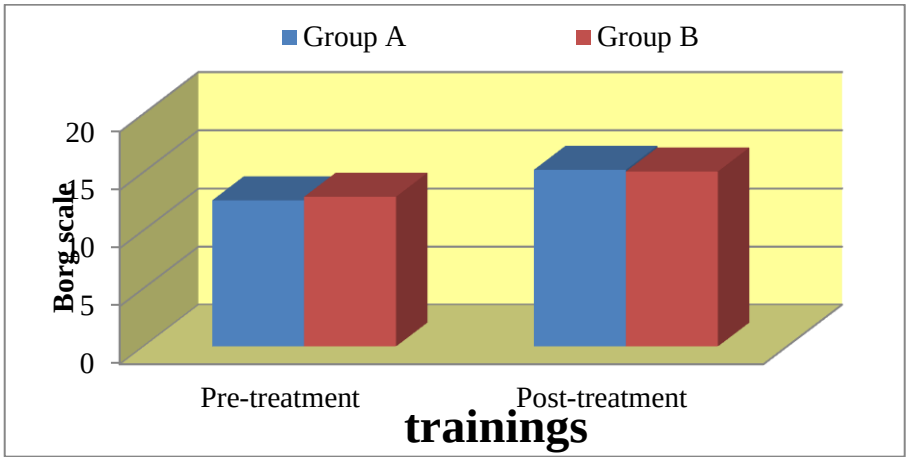


Figure (4):Show mean values of pre- and pos tBorg scale between both groups



3- Borg scale: there were significant differences between pre- and post-Borg scale within group A and group B (P=0.0001; P<0.05), while there were no significant differences in pre-Borg scale (P=0.398; P>0.05) and post-Borg scale (P=0.677; P>0.05) between groups A and B as shown in tables (5) and demonstrated in figure (4).

DISCUSSION

The findings of this study showed that breathing exercise had valuable effect more than

Powerlung device on respiratory muscles training in normal adults with change effect in expiratory thickness (↓18.56% and ↓1.18%) in Group A and Group B respectively , for inspiratory thickness (↓3.29% and↑ 5.03%) in Group A and Group B respectively and in diaphragmatic excursion (↓ 1.40% and ↓3.03%) . So there was significant difference between Group A and Group B in post-ins. thickness and in post-exs. thickness while no significant differences in post-diaphragmatic excursion according to ultrasongraphy assessment . There were significant differences between pre- and post-Borg scale within group A and group B (P=0.0001; P<0.05) with increased percentage 20.91% and16.84% for group A and group B respectively ,while there were no significant differences in pre-

Borg scale (P=0.398; P>0.05) and post-Borg scale (P=0.677; P>0.05) between groups A and B.

This study agreed with (Barbalho-Moulim et al., 2011) who evaluated the effect of IMT (inspiratory muscle training) on Sixty-five patients who were candidates for elective open bariatric surgery, aged 21-52 years, Diaphragmatic excursion was evaluated, According to the results of the study, there was no increase in the diaphragmatic excursion after the training period and this might due to the effect of obesity.

Results of this study agreed with (Watsford, and Murphy.2008) who demonstrated that there was 8% reduction within-group of RM training in RPEB(Rate of perceived exertion) indicates the positive implications for dyspnea after RM training using power lung device in older adults so RM training causes specific training adaptations in older adults.

The results of this study disagreed (Kaneko et al.,2009) who used ultrasonography and spirometry to determine the function of the respiratory muscles during breathing exercises and the results showed that diaphragmatic breathing had a significant effect on diaphragmatic thickness which increased by 24, 9 % in healthy males with average age 21,8±1,9.

In contrast results achieved by (Enright et al., 2006) who studied the effect of high intensity IMT on diaphragm thickness and exercise capacity. The study was done on twenty moderately trained adults of both sexes (9 male, 11 female) who were healthy and who were students attending the University of Salford (United Kingdom). Training was performed 3 times per week day after day for 8 weeks .The finding of the study revealed that high intensity IMT resulted in increased contracted diaphragm thickness and exercise capacity in

healthy subjects.

The results of this study disagreed with (Mahmoud et al.2012) who revealed that IMT intervention significantly improved diaphragmatic excursion in post thoracotomy patients. In the study of (Mahmoud et al.,2012) thirty patients after thoracotomy assigned into two groups equal in number; study group who received IMT and traditional physical therapy, and control group who received the traditional physical therapy only. The training program for patients in both groups was three times per week twice daily for one month, diaphragmatic excursion were measured by ultrasonography for all patients participated in this study post operatively after discharge from ICU (3rd day post-operative) and after finishing the training program (one month).

The results of this study disagreed with (Yamaguti et al., 2012) who evaluated the effect of diaphragmatic breathing exercise in patients with chronic obstructive pulmonary disease. The diaphragmatic excuersion was showed greater improvement after 4-week of DBTP (diaphragmatic breathing training program) in the training group than did the CG (control group) (F=15.08; P<.001). In each session, the patients were instructed to perform a total of 150 breathing exercises in the following positions: supine, right and left lateral position, sitting, and standing (3 series of 10 repetitions in each position). Between each set of DB exercises, patients were instructed to breathe normally for 1 minute, and then performed a slow maximal inspiration allowing the air to go to the belly of the patient," and "performed a normal expiration without forcing abdominal retraction.

CONCLUSION

The findings of this study showed that breathing exercise had valuable effect more than Power lung device on respiratory muscles training in normal adults with change effect in expiratory thickness (↓18.56% and ↓1.18%) in Group A and Group B respectively , for inspiratory thickness (↓3.29% and↑ 5.03%) in Group A and Group B respectively and in diaphragmatic excursion (↓ 1.40% and ↓3.03%) . So there were significant difference between Group A and Group B in post-ins. thickness and in post-exs. thickness while no significant differences in post-diaphragmatic excursion according to ultrasonography assessment . There were significant differences between pre- and post-Borg scale within group A and group B (P=0.0001; P<0.05) with increased percentage 20.91% and16.84% for group A and group B respectively ,while there were no significant differences in pre-Borg scale (P=0.398; P>0.05) and post-Borg scale(P=0.677; P>0.05) between groups A and B.

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CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

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AUTHOR CONTRIBUTIONS

GAA designed and performed the experiments and also wrote the manuscript.HME, NGE and KMK performed *continuous guidance and suggestions* during the performance of experiments, data analysis and reviewed the manuscript. All authors read and approved the final version.

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