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DEEP BREATHING TRAINING IN CONNECTION TO MODERATE PHYSICAL ACTIVITY CAN BE BENEFICIAL IN MILDLY OBESE MEN

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Abstract. Sixteen overweight men were submitted to 3 months of moderate-intensity training connected with respiratory muscle training: deep breathing (DB) and breathing through a tube (BT). All subjects underwent 2 identical control tests (C1 and C2), at the treadmill speeds 4, 5 and 6 $km \cdot h^{-1}$. During the test heart rate (HR), oxygen uptake (VO_2), respiratory exchange ratio (RER), breathing frequency (B_f), tidal volume (T_V), and minute ventilation (V_E) were measured, as well as forced vital capacity (FVC), maximal voluntary ventilation (MVV), peak inspiratiory pressure (INSPp), peak expiratory pressure (EXPp), holding pressure during inspiration (HPinsp) and holding pressure during expiration (HPiexp.) The same protocol was repeated after the training (T). The HR and VO_2 were no changed by training, RER was lower in DB (0.82±0.01) than in BT (0.92±0.01, $p<0.01$). The B_f decreased and T_V increased after training only in DB. The V_E became elevated gradually with the increased treadmill speed in both groups of subjects. After training MVV was similar in DB and BT subjects, FVC was significantly increased in DB group ($p<0.04$), INSPp increased significantly in both DB and BT ($p<0.03$ and $p<0.01$, respectively), whereas EXPp did not change. The Hpinsp increased only in BT $p<0.01$, and Hpexp only in DB ($p<0.04$). The present study showed that in moderately obese men deep breathing training changes favorably the pulmonary function. The exercise-induced decrease of RER after DB training suggests increased contribution of fat oxidation to total energy expenditure.

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Key words: Whole body training - Respiratory muscle training - Pulmonary functions

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Introduction

Most data suggest that physical activity in obese people is much less intensive than that in people with normal body mass. Overweight subjects often find the exercise prescription difficult to follow, since they get extremely tired even walking at the peace recommended by medical doctors. Moreover, the breathing patterns of lean and moderately obese subjects differ also at similar relative exercise intensities. In obese subjects the breathing frequency is higher and the tidal volume is lower than in lean subjects [23].

In our previous study [9] it was found that in obese subjects changes in the breathing pattern were the earliest and most prominent effects of moderate-intensity walking training. After training the breathing frequency of these subjects decreased while tidal volume increased without any alterations in minute ventilation. Ramirez *et al.* [15] demonstrate that the whole body training improved strength and endurance of the respiratory muscles, while McConnell *et al*. [13] reported lowered breathlessness and decreased perception of breathlessness in heart failure patients.

Numerous human studies have shown that specific respiratory muscle training improves also breathing and cycling endurance similarly to the effects noted after performing endurance exercise, at least when the exercise tests require the subjects to work at about 70-80% of their maximal capacity or less [2,4,8,11,12,]. However, the mechanism by which respiratory muscle training improves exercise performance still remains unclear, although a popular idea is that minute ventilation becomes levered [2,3,4].

The purpose of the present study was to compare two techniques of respiratory muscle training: breathing exercises using Yoga technique – deep breathing (DB group) and breathing through a tube utilizing expiration against resistance (BT group). The respiratory muscle training was performed together with the whole body training.

Materials and Methods

Subjects: Sixteen overweight subjects, not participating in any regular physical activity gave their written informed consent to participate in this study. The research procedure was approved by the Ethics Committee of the Kuopio University (Finland). The subjects characteristics is presented in Table 1.

Table 1
Characteristics of subjects

	Group DB	Group BT
Age (yrs)	49.8±4.4	42.9±7.2
Height (cm)	177.5±7.3	178.6±5.7
BMI	29.9±1.2	29.2±1.0

Mean ±SD

Pulmonary function tests and resting electrocardiograms were performed as initial screenings. No subjects had a history of asthma, cardiovascular disease, or musculoskeletal abnormalities.

Experimental procedure: The subjects underwent two control exercise tests 2-3 days apart (C1 and C2). The C1 test served as familiarization to treadmill and all testing procedures, and the C2 test was used to compare the results obtained after training (T). Each test included three treadmill running exercises, starting at the treadmill speed of 4 $km \cdot h^{-1}$, and increased by 1 $km \cdot h^{-1}$ at the end of each 4 min stage. During the test the respiratory gas exchange was analyzed continuously with Medikro 919 gas analyzer (Medikro Ltd, Kuopio, Finland) and computed every 30 s. Besides, the tidal volume (TV), respiratory frequency (B_f) and minute ventilation (V_E) were recorded. Heart rate (HR) was measured using Sport Tester heart rate monitors (Polar Electro Ltd, Kempele, Finland) before and during the whole test. The rate of perceived exertion (RPE) was registered at the end of each running speed.

On the next day the pulmonary function was evaluated on the base of measurements of forced vital capacity (FVC), maximal voluntary ventilation (MVV), peak inspiratory pressure (INSPp), peak expiratory pressure (EXPp), holding pressure during inspiration (HPinsp) and holding pressure during expiration (HPiexp).

When the treadmill test and all measurements were done the subjects started the uncontrolled moderate-intensity walking training (without any changes in their usual diet). They walked for one month 30 min or more per day and most preferably for all days of the week, as recommended by both the Centers for Disease Control and Prevention and the American College of Sports Medicine [14]. After one month of training the subjects were randomly divided into two groups: the DB group besides everyday walking was taught to be aware of the different phases of their breathing. Deep breath training was done during the walking. The subjects breathed through the nose. Exhaling and inhaling lasted both for about 4-8 seconds. The key element of this training was the proper use of the diaphragm.

The aim of the second group (BT) was to increase the respiratory muscle strength and elasticity of the chest wall. The subjects breathed through a tube (BA-Tube – bronchitis aid tube), in which the resistance could be regulated by seven orifices: the smaller orifice the greater the resistive load. The principle was the same as exhalation through a tube into a bottle with water or use of a PEP mask (Positive Expiratory Pressure).

Each training session lasted 10-15 min every day besides of the walking training. After finishing three months of training the treadmill tests and all measurements were repeated with the subjects.

Statistic: Statistical significance of differences before and after training were compared using the depended t test as compared differences between tests. For comparison differences between groups the independent t test was used.

Significance was set at the $p<0.05$ level of confidence. All data are reported as means±SE.

Results

Physiological variables: Heart rate (HR) and oxygen uptake ($V0_2$) were not affected by the applied two types of training.

Respiratory exchange ratio (RER): The post training changes in RER were noticed only in DB group. At the running speed of 6 $km \cdot h^{-1}$ the value of RER was 0.82±0.01 and it was significantly lower from that (0.92±0.01) found in BT group ($p<0.01$).

Breathing frequency (B_f): was not effected by training in BT subjects. In DB subjects B_f was significantly lower after training than in C2 tests at the running speeds of 4 and 5 $km \cdot h^{-1}$ ($p<0.03$ and $p<0.05$, respectively, Fig. 1).

Tidal volume (T_V): The T_V was not affected by training in BT group whereas in DB group T_V increased after training in comparison with corresponding values found in C2 test at the running speeds of 4 and 5 $km \cdot h^{-1}$ ($p<0.02$ and $p<0.05$, respectively, Fig. 1).

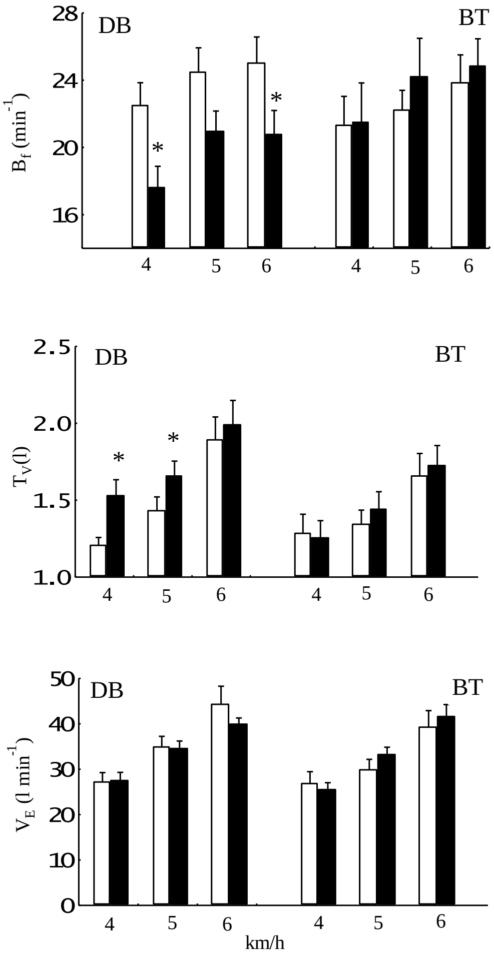

Fig. 1
Mean values (±SE) of breathing frequency (Rf), tidal volume (T_V) and minute ventilation (V_E) in two group of subjects (DB and BT) performing 3 graded incremental tests on the treadmill – 4, 5 and 6 km·h^{-1}.
White columns - the second control test (C2), black columns - values obtained after training (T3).
*Significance differences between C2 and T3 tests.

Minute ventilation (V_E): elevated gradually with the increase of treadmill speed. These changes were similar before and after training in both group of subjects (Fig. 1).

Respiratory variables before and after training: (Table 2).

Table 2
Mean±SE of maximal voluntary ventilation (MMV), forced vital capacity (FVC), peak inspiration pressure (INSPp), peak expiration pressure (EXPp), holding pressure during inspiration (HPinsp), holding pressure during expiration (HPexp),) in 2 groups of subjects before and after 3 months of training

Variables	Group DB before training	Group DB after training	Group BT before training	Group BT after training
MVV (l)	176.9±13.3	185.7±14.8	177.1±7.5	179.9±7.4
FVC (l)	5.19±0.29	5.45±0.34*	5.30±0.24	5.33±0.19
INSPp (cmH_20)	11.9±0.9	13.8±0.92*	9.8±079	12.3±0.8*
EXPp (cmH_20)	18.2±1.0	19.1±0.8	16.4±1.0	16.4±1.0
HPinsp (cmH_20)	10.01±1.0	12.1±1.0	8.8±0.6	10.8±0.8*
HPexp (cmH_20)	17.2±1.1	18.5±0*	15.2±1.2	15.4±1.2

*as compared with the respective values before training

Table 2 shows that after 3 months of training maximal voluntary ventilation (MVV) was similar in both groups of subjects. Forced vital capacity (FVC) was significantly increased in DB group ($p<0.04$). A peak inspiratory pressure (INSPp) increased significantly in both DB and BT subjects ($p<0.03$ and $p<0.01$, respectively), whereas peak expiratory pressure (EXPp) did not change. The holding pressure during inspiration (Hpinsp) increased only in BT group $p<0.01$). The holding pressure during expiration (Hpexp) increased significantly only in DB group ($p<0.04$).

Rating of perceived exertion (RPE): The subjective feeling of exertion during the successive running speeds was similar in DB and BT groups and their ratings varied from 8.7±0.6, and 9.5±0.7 at the speed of 4 $km \cdot h^{-1}$, to 10.7±0.8 and 11.1±0.7 at the running speed of 6 $km \cdot h^{-1}$.

Discussion

The important finding of the present study is that the training of respiratory muscles together with the whole body training is beneficial for mildly obese subjects since it change advantageously their respiratory pattern. It should be, however, emphasized that these changes mostly concerned the group of subjects who joined deep breathing with whole body training (DB). After training, only in DB subjects tidal volume was significantly higher and breathing frequency lower without any significant changes in minute ventilation. Lack of changes in V_E after the respiratory muscle training was also noted in non-obese persons [11,17,18].

The advantageous changes in the breathing pattern after the whole body training were described in our previous study [9]. Such changes of breathing seem to be particularly important in obese subjects, because in obesity the respiratory resistance and work breathing is increased and lung volumes decreased [1,11,16]. It was reported that in healthy men the respiratory muscle training improved breathing and cycling performance, however, these changes were not related to cardiovascular adaptation but they occurred as result of attenuated fatigue of respiratory muscles.

The beneficial influence of deep breathing on respiratory function was previously observed in normal male subjects [10] and in asthmatics [22]. The respiratory muscle training is often applied to prevent the post-operative pulmonary complications, especially in high-risk patients such as obese persons [6].

Significance of deep breathing (DB) and positive expiratory pressure (PEP) training were compared in severely obese men with BMI >40 [7]. The authors found that tidal volume and alveolar ventilation were higher and breathing frequency lower during DB exercise and the peak of the inspiratory volume was also more elevated during DB than during PEP exercises. Although in the above mentioned pulmonary changes did not concerned the post training state they could serve us to conclude that in our subjects DB technique was superior to the sustained BT in reference to improvement of pulmonary functions.

It can be believed that favorable changes of the respiratory pattern found in the present study in DB subjects and increase in their forced vital capacity indicate less restriction of the lungs and then greater possibility to take a deeper breath, which is often limited in obese persons. Increased forced vital capacity and maximum breathing holding time were previously reported after muscle training in non-obese subjects [10] as well as in patients with chronic obstructive pulmonary disease [5].

Interesting finding of the present study was that post training values of RER were decreased in DB subject during the treadmill exercise. Therefore, it could be supposed that contribution of fat oxidation to total energy expenditure could be increased in DB subjects in the work condition. Similar results were obtained in the study of Van Aggel *et al.* [20], in which upper and lower body obese women were submitted to whole body training. The authors found that RER, as well as plasma free fatty acid oxidation were also increased during exercise but only in upper body obese women (the typical obesity for men). The data on the effect of aerobic exercise training on the exercise fat oxidation are controversial but suggest that exercise training may not be able to increase fat oxidation at rest [19-21]. A significant decrease of serum triacylgricerols and total cholesterol under resting condition were described by Suzuki *et al.* [19] not before of 20 months of training.
Summarizing. The present study showed that in moderately obese men deep breathing training changes more favorably the pulmonary function than that utilizing expiration against resistance. Moreover, exercise-induced decrease of RER values after deep breathing training suggests that contribution of fat oxidation to total energy expenditure during exercise could be elevated.

References

1. Babb T.G., E.R.Buskirk, J.L.Hodgson (1989) Exercise end-expiratory lung volumes in lean and moderately obese women. *Int.J.Obes.* 13:11-19

2. Boutellier U., R.Buchel, A.Kundert, C.Spengler (1992) The respiratory system as an exercise limiting factor in normal trained subjects. *Eur.J.Appl.Physiol.* 65:347-353

3. Boutellier U. (1998) Respiratory muscle fitness and exercise endurance in healthy humans. *Med.Sci.Sports Exerc.* 30:1169-1172

4. Boutellier U., P.Piwko (1992) The respiratory system as an exercise limiting factor in normal sedentary subjects. *Eur.J.Appl.Physiol.* 64:145-152

5. Esteve F., N.Blanc-Gras, J.Gallego, G.Benchetrit (1996) The effects of breathing pattern training on ventilatory function in patients with COPD. *Biofeedback Self Regul*. 21:311-32

6. Fagevik O.M., I.Hahn, S.Nordgren, H.Lonroth, K.Lundholm (1997) Randomized controlled trial of prophylactic chest physiotherapy in major abdominal surgery. *Br.J.Surg.* 84:1535-1538

7. Fagevik O.M., H.Lonroth, B.Bake (1999) Effects of breathing exercises on breathing patterns in obese and non-obese subjects. *Clin.Physiol.* 3:251-257

8. Holm P., A.Sattler, R.F.Fregosi (2004) Endurance training of respiratory muscles improves cycling performance in fit young cyclists. *BMC Physiol.* 4:9

9. Kruk B., H.Pekkarinen, O.Hanninen (2003) Respiratory response to walking training in overweight men. *Biol.Sport* 20:281-288

10. Makwana K., N.Khirwadkar, H.C.Gupta (1988) Effect of short term yoga practice on ventilatory function test. *Indian J.Physiol.Pharmacol.* 32:202-208

11. Markov G., Ch.M.Spengler, C.Knopfli-Lenzin, C.H.Stuessi, U.Boutellier (2001) Respiratory muscle training increases cycling endurance without affecting cardiovascular responses to exercise. *Eur.J.Physiol.* 85:233-239

12. McConnell A.K., L.M.Romer (2004) Respiratory muscle training in healthy humans: resolving the controversy. *Int.J.Sports Med.* 25:284-293

13. McConnell T.R., J.S.Mandak, J.S.Sykes, H.Fesniak, H.Dasgupta (2003) Exercise training for heart failure patients improves respiratory muscle endurance, exercise tolerance, breathlessness, and quality of life. *J.Cardiopulm.Rehabil.* 23:10-16

14. Pate R.R., M.Pratt, S.N.Blair, W.L.Haskell, C.A.Macera, C.Bouchard, D.Buchner, W.Ettinger, G.W.Heath, A,C.King et al. (1995) Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports. *JAMA* 273:402-407

15. Ramirez-Sarmiento A., M.Orozco-Levi, R.Guell, E.Barreiro, N.Hernandez, S.Mota, M.Sangenis, J.M.Broquetas, P.Casan, J.Gea (2002) Inspiratory muscle training in patients with chronic obstructive pulmonary disease: structural adaptation and physiologic outcomes. *Am.J.Respir.Crit.Care Med.* 166:1491-1497

16. Ray C.S., D.Y.Sue, G.A.Bray, J.E.Hansen, K.Wasserman (1983) Effects of obesity on respiratory function. *Am.Rev.Respir.Dis.* 128:501-506

17. Sonetti D.A., T.J.Wetter, D.F.Pegelow, J.A.Dempsey (2001) Effects of respiratory muscle training versus placebo on endurance exercise performance. *Respir.Physiol.* 127:185-199

18. Stuessi C., C.M.Spengler, C.Knopfli-Lenzin, G.Markov, U.Boutellier (2001) Respiratory muscle endurance training in humans increases cycling endurance without affecting blood gas concentration. *Eur.J.Appl.Physiol.* 84:582-586

19. Suzuki I., T.Nagaya, N.Machita, J.Z.Ching, A.Ito(1996) Effects of long-term physical training on body composition, cardiovascular function, and serum lipids In mildly obese middle-aged subjects. *Nippon Eiseigaku Zasshi* 50:1047-56

20. Van Aggel-Leijssen D.P., W.H.Saris, A.J Wagenmakers, G.B Hul, M.A van Baak (2001) The effect of low-intensity exercise training on fat metabolism of obese women. *Obes.Res.* 9:86-96

21. Van Baak M.A. (1999) Exercise training and substrate utilization in obesity. *Int.J.Obes.Relat.Metab.Disord.* 23(Suppl.):S11-17

22. Vedanthan P.K., L.N.Kesavalu, K.C.Murthy, K.Duvall, M.J.Hall, S.Baker, S.Nagarathna (1998) Clinical study of yoga techniques in university students with asthma: a controlled study. *Allergy Asthma Proc.* 19:3-9

23. Whipp B.J., J.A.Davis (1984) the ventilatory stress of exercise obesity. *Am.Rev.Respir.Dis.* 129(Suppl.): 590-592

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