Laser Acupuncture Therapy Added to Inspiratory Muscle and Aerobic Exercise Training Improves Small Airway Ventilation in Metal Arc Welders

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ABSTRACT

The adverse effects of arc welding on pulmonary function have been previously documented. Long-term exposure to welding gases and fumes reduced flows in small airways of welders. The aim of this study was to compare two types of treatment protocols to determine small airway ventilation response to aerobic exercise training and inspiratory muscle training with or without laser acupuncture therapy in metal arc welders. Fifty metal arc welding workers who practiced welding job for no less than ten years were enrolled in this study their age ranged from 25 to 40 years and were included in two equal groups. The first group (A) received aerobic exercise training and inspiratory muscle training with low intensity laser therapy for the respiratory system. The second group (B) received aerobic exercise training and inspiratory muscle training. The program consisted of three sessions per week for two months. This study indicated that there was a significant improvement in measures of small airway ventilation in both groups. The differences between both groups were significant, where results of group (A) showed a greater significant changes than group (B). These results support the use of laser acupuncture therapy in addition to the aerobic exercise training and inspiratory muscle training to improve small airway ventilation in metal arc welders.

Key words: *Aerobic exercise, inspiratory muscle, training, laser acupuncture, arc welding*

Metal Ark Kaynakçılarında İnspiratuar Kas ve Aerobik Egzersiz Eğitimine Lazer Akapunktur Tedavisinin Eklenmesi Küçük Havayolu Ventilasyonunu Düzeltir

ÖZET

Ark kaynağının akciğer fonksiyonu üzerindeki olumsuz etkileri önceden belgelenmiştir. Kaynak gazlara ve dumanlara uzun süre maruz kalma, kaynakçıların küçük hava yollarındaki akımı azaltır. Bu çalışmanın amacı, metal ark kaynakçılarında aerobik egzersiz eğitimi ve lazer akupunktur tedavisi ile birlikte veya sadece inspiratuar kas eğitimini içeren iki tedavi protokolünü, küçük hava yolu havalanma yanıtını belirlemek için karşılaştırmaktır. En az on yıldır kaynak işinde çalışan 50 işçi çalışmaya alındı. Yaşları 25 ile 40 arasında değişmekteydi ve iki eşit gruba bölündüler.Birinci grup (A) aerobik egzersiz eğitimi ve solunum sistemi için düşük yoğunluklu lazer tedavisi ile solunum kas eğitimi aldı. İkinci grup (B) aerobik egzersiz eğitimi ve inspiratuar kas eğitimi aldı. Program iki ay boyunca haftada üç oturumdan oluştu. Bu çalışmada her iki gruptada küçük hava yolu havalanması ölçümlerinde önemli gelişme olduğunu tespit edildi. Her iki grup arasındaki fark anlamlı idi, (A) grubu sonuçları grup (B) den daha fazla anlamlı değişiklikler gösterdi. Bu sonuçlar metal ark kaynakçılarında, küçük hava yolu havalanmasını iyileştirmek için aerobik egzersiz eğitimi yanı sıra lazer akupunktur tedavisinin kullanımını ve inspiratuar kas eğitimini desteklemektedir.

Anahtar kelimeler: *Aerobik egzersiz, solunum kasları, eğitim, lazer akupunktur, ark kaynağı*

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INTRODUCTION

Welding is a common task in many occupations and only 7% of the individuals actually called themselves welders and flame cutters, while the largest groups doing welding worked in construction or were motor, agricultural and industrial mechanics and fitter (1). Welding fumes can cause a variety of adverse health effects as occupational asthma, bronchitis, pneumoconiosis, and lung cancer. Certain metal and gas components generated in welding fumes have been linked with inflammation and oxidative stress in welders with long-term exposure (2,3). The adverse effects of arc welding on pulmonary function have been previously documented. Long-term exposure to welding gases and fumes reduced flows in small airways of welders (4). Welding workers, with exposure longer than 9 years, showed a significant reduction in forced expiratory volume in one second (FEV_1)/forced vital capacity (FVC) and four parameters of forced expiratory flow ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, $FEF_{25-75\%}$) levels (5). This effect primarily shows an obstructive pattern of airways disease as long-term exposure to arc welding gases and fumes reduced flows in small airways of welders. Preventive measures should be taken to improve the health status of these workers (6).

Diaphragmatic breathing improves the clinical status of the subjects, reduces air trapping, airway resistance, trapezius muscle use during respiration, respiratory rate and improves lung compliance and the mean forced expiratory flow during the middle half of forced vital capacity and a modest increase in forced vital capacity (7). Physical activity is important in children with asthma such as running and bicycling are associated with improved fitness and decreased severity of asthma symptoms (8). Laser acupuncture therapy may cause many reactions and biological effects within the human body. Therefore it is recommended as a therapeutic modality in management of chronic inflammatory conditions due to its anti-inflammatory and immunocorrecting action (9). The aim of this study was to compare two types of treatment protocols to determine small airway ventilation response to aerobic exercise training and inspiratory muscle training with or without laser acupuncture therapy in metal arc welders.

MATERIALS AND METHODS

Subjects

Fifty metal arc male welders who practiced welding job for no less than ten years were enrolled in this study their age ranged from 25 to 40 years and were included in two equal groups. The first group (A) received aerobic exercise training and inspiratory muscle training with laser acupuncture therapy for the respiratory system. The second group (B) received aerobic exercise training and inspiratory muscle training. The program consisted of three sessions per week for two months. Informed consent was obtained from all participants. All participants were free to withdraw from the study at any time. If any adverse effects had occurred, the experiment would have been stopped. However, no adverse effects occurred, and so the data of all the participants were available for analysis.

Evaluated parameters

Small airway ventilation was measured using spirometer (Schiller Spirovit Sp-10, Swizerland) included the average of forced expiratory flow at 0.2-1.2% of forced vital capacity ($FEF_{0.2-1.2\%}$), the average of forced expiratory flow at 25-75% of forced vital capacity ($FEF_{25-75\%}$), the average of forced expiratory flow at 75-85% of forced vital capacity ($FEF_{75-85\%}$), maximum expiratory flow at 75% of forced vital capacity ($MEF_{75\%}$) and maximum expiratory flow at 50% of forced vital capacity ($MEF_{50\%}$).

Aerobic exercise training

The aerobic treadmill-based training programme (PRECOR 9.1/ 9.2, China) was set to 60% - 75% of the maximum heart rate (HRmax) achieved in a reference to the modified Bruce protocol (10). This rate was defined as the training heart rate (THR). After an initial, 5-minute warm-up phase performed on the treadmill at a low load, each endurance training session lasted

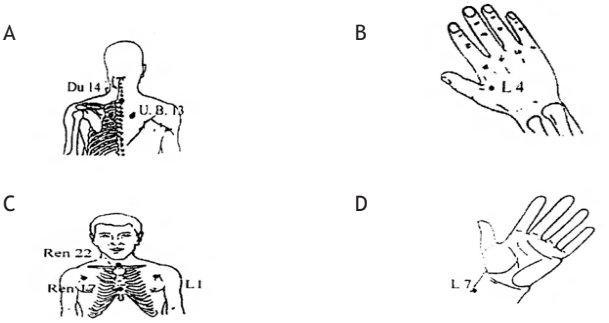

Figure 1*. (A, B, C and D): The acupuncture points for the respiratory system disorders (11).*

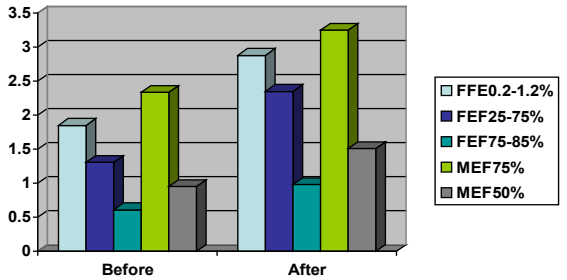

***Figure 2**. Mean value of $FEF_{0.2\text{-}1.2\%}$, $FEF_{25\text{-}75\%}$, $FEF_{75\text{-}85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (A) before and after treatment.*

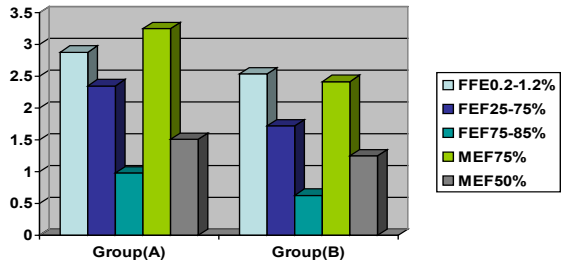

***Figure 4**. Mean value of $FEF_{0.2\text{-}1.2\%}$, $FEF_{25\text{-}75\%}$, $FEF_{75\text{-}85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (A) and group (B) after treatment.*

30 minutes and ended with 5-minute recovery and relaxation phase. All patients performed three weekly sessions (i.e. a total of 36 sessions per patient over a 3-month period (10).

Laser acupuncture therapy

Laser LTU 904 retroflected shield (class I laser product manufactured by laserex technologies PTYLTD, Australia) was used to apply laser acupuncture therapy for the respiratory system, while the patient was in the sitting position bare skin of the site of laser application, back was supported hips and knees were 90° flexion and feet rest on the floor (11). Each acupuncture point of the respiratory system disorders received laser for 90 seconds, three sessions per week for four successive weeks. The acupuncture (L.1), shamzhong (Ren 17), Tiantu (Ren 22), feishu (U.B.B), Dazhui (Du 14), lieque (L.7) and Heagu (L.I.4) (11). Figure 1 (A, B, C and D).

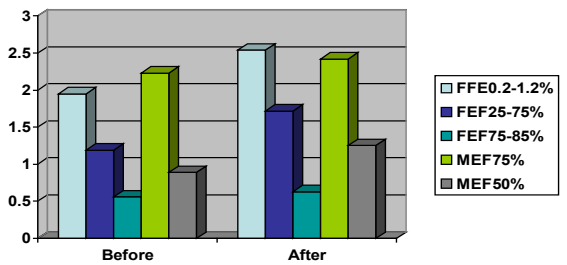

***Figure 3**. Mean value of $FEF_{0.2\text{-}1.2\%}$, $FEF_{25\text{-}75\%}$, $FEF_{75\text{-}85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (B) before and after treatment.*

Inspiratory muscle training

Inspiratory muscle training was applied in the form of diaphragmatic breathing exercise (12). The patient was asked to sit in bed with his or her back completely supported and both hips and knees slightly flexed to gain relaxation of the abdominal and hamstring muscles and asked to put both hands over the umbilical area. The patient was directed to inhale slowly through his nose, then was told to watch movement of chest and rises of therapist's hand (on the xiphoid process) as inspiration was going on. This exercise had been practiced until the patient requires no assistance or advice. Diaphragmatic breathing exercise was applied (under close supervision of chest physiotherapist) for three times then rest for 30 seconds and this maneuver was repeated for 15 minutes/session, three sessions per week for two months (12).

Statistical analysis

The mean values of forced expiratory flow at 0.2-1.2 % of forced vital capacity ($FEF_{0.2\text{-}1.2\%}$), forced expiratory flow at 25-75% of forced vital capacity ($FEF_{25\text{-}75\%}$), forced expiratory flow at 75-85% of forced vital capacity ($FEF_{75\text{-}85\%}$), maximum expiratory flow at 75% of forced vital capacity ($MEF_{75\%}$) and maximum expiratory flow at 50% of forced vital capacity ($MEF_{50\%}$) obtained before and after two months in both groups were compared using paired "t" test. Independent "t" test was used for the comparison between the two groups ($p<0.05$).

***Table 1**. Mean, standard deviation and significance of $FEF_{0.2-1.2\%}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (A) before and after treatment.*

	Mean±SD		t value	Significance
	Before	After		
$FEF_{0.2-1.2\%}$ (L/sec.)	1.85±0.45	2.88±0.51	4.67	p< 0.05
$FEF_{25-75\%}$ (L/sec.)	1.31±0.26	2.35±0.42	4.80	p< 0.05
$FEF_{75-85\%}$ (L/sec.)	0.61±0.26	0.98±0.28	3.74	p< 0.05
$MEF_{75\%}$ (L/sec.)	2.34±0.51	3.25±0.53	3.76	p< 0.05
$MEF_{50\%}$ (L/sec.)	0.95±0.41	1.51±0.47	3.86	p< 0.05

$FEF_{0.2-1.2\%}$ = Forced expiratory flow at 0.2-1.2% of forced vital capacity, $FEF_{25-75\%}$ = Forced expiratory flow at 25-75% of forced vital capacity, $FEF_{75-85\%}$ = Forced expiratory flow at 75-85% of forced vital capacity, $MEF_{75\%}$ = Maximum expiratory flow at 75% of forced vital capacity, $MEF_{50\%}$ = Maximum expiratory flow at 50% of forced vital capacity,

RESULTS

The mean $FEF_{0.2-1.2\%}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ values were significantly higher in both groups after treatments (Table 1and 2, Figure 2 and 3). There were statistically significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment (Table 3 and Figure 4). These results support the use of laser acupuncture therapy in addition to the aerobic exercise training and inspiratory muscle training to improve small airway ventilation in metal arc welding workers.

DISCUSSION

The aim of this study was to compare two types of treatment protocols to determine small airway ventilation response to aerobic exercise training and inspiratory muscle training with or without laser acupuncture therapy in metal arc welders. The results of this study indicated that the mean $FEF_{0.2-1.2\%}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ values were significantly higher in both groups after treatments and there were statistically significant differences between mean values of the investigated parameters in group (A) and group (B) after treatment (Table 1, 2 and 3).The results of this study were in concordance with previous studies demonstrating that in welding workers, the improvement in small airway ventilation in welders after diaphragmatic breathing exercise, aerobic exercise training in addition to laser acupuncture therapy might be related to broncholytic effect, disappearance of inflammatory changes in bronchial mucosa, improved potency of airways and respiratory muscles strength. Diaphragmatic breathing exercise is associated with improvement in inspiratory muscles strength and endurance that may help to relieve the sensation of dyspnea (13). Also, diaphragmatic breathing enhances lower lung ventilation, reduces residual volume, improves airflow in small airways and as a result reduces pulmonary hyperinflation in patients with chronic obstructive lung disease (14). In asthmatic patients diaphragmatic breathing exercise increased the inspiratory muscles strength and therefore increases the expiratory flow as asthmatic patients are exposed to airway obstruction and hyperinflation which by itself adversely affects the inspiratory muscles by forcing them to operate in an inefficient part of the length tension relationship (15, 16)

Exercise training may reduce the perception of breathlessness through a number of mechanisms includes strengthening of respiratory muscles (17). Pulmonary

***Table 2**. Mean, standard deviation and significance of $FEF_{0.2-1.2\%}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (B) before and after treatment.*

	Mean ± SD		t value	Significance
	Before	After		
$FEF_{0.2-1.2\%}$ (L/sec.)	1.95±0.52	2.54±0.57	3.11	p< 0.05
$FEF_{25-75\%}$ (L/sec.)	1.19±0.36	1.72±0.43	2.95	p< 0.05
$FEF_{75-85\%}$ (L/sec.)	0.56±0.27	0.63±0.31	2.12	p< 0.05
$MEF_{75\%}$ (L/sec.)	2.23±0.56	2.42±0.59	2.67	p< 0.05
$MEF_{50\%}$ (L/sec.)	0.89±0.29	1.25±0.37	3.09	p< 0.05

***Table 3**. Mean, standard deviation and significance of $FEF_{0.2-1.2\%}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $MEF_{75\%}$ and $MEF_{50\%}$ in group (A) and group (B) after treatment.*

	Mean ± SD		t value	Significance
	Group (A)	Group (B)		
$FEF_{0.2-1.2\%}$ (L/sec.)	2.88±0.51	2.54±0.57	4.19	p< 0.05
$FEF_{25-75\%}$ (L/sec.)	2.35±0.42	1.72±0.43	3.88	p< 0.05
$FEF_{75-85\%}$ (L/sec.)	0.98±0.28	0.63±0.31	3.31	p< 0.05
$MEF_{75\%}$ (L/sec.)	3.25±0.53	2.42±0.59	3.71	p< 0.05
$MEF_{50\%}$ (L/sec.)	1.51±0.47	1.25±0.37	4.48	p< 0.05

rehabilitation programs involve upper and lower limbs exercise, usually treadmill or bicycle ergometer can increase walking distance and health related quality of life in people with asthma (18). Supervised aerobic training program for two months, three sessions every week for thirty minutes per session in children with moderate to severe stable asthma improved their cardiorespiratory fitness. Also; exercise training reduced the daily use of both inhaled and oral steroids (19). Laser can be used a component of combined treatment in management of chronic bronchitis and bronchial asthma as it produced marked broncholytic effect, reduction of cough and improvement of general condition due to its anti inflammatory and a good immunocorrecting action (20, 21).

The expected and logic cause of additional improvement in small airway ventilation of group (A) received aerobic exercise training and inspiratory muscle training with laser acupuncture therapy for the respiratory system may be due to reduction of inflammatory changes in bronchial mucosa, activation of proliferative processes and normalization of bronchial secretion, good immunocorrection effect, anti-inflammatory effect and improved patency of the small airways as a result of laser acupuncture therapy.

In conclusion, laser acupuncture therapy added to the aerobic exercise training and inspiratory muscle training improves small airway ventilation in metal arc welders.

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REFERENCES

1. *Lillienberg L, Zock P, Kromhout H, et al. A Population-Based Study on Welding Exposures at Work and Respiratory Symptoms. Annals of Occupational Hygiene 2008; 52:107-15.*
2. *Stark M, Zubareb J, Jacovovitz R, et al. HO-1 and VEGF gene expressions are time dependant during exposure to welding fumes. Cytokine 2009; 46: 290-5.*
3. *Fireman E, Lerman Y, Stark M, Schwartz Y, Ganor E, Grinberg N. Detection of occult lung impairment in welders by induced sputum particles and breath oxidation. Am J Ind Med 2008; 51: 503-11.*
4. *Kilburn K, Warshaw R. Pulmonary functional impairment from years of arc welding, The American Journal of Medicine 1989; 87: 62-9.*
5. *Tejral J, Fiala Z, Andrys C. Health status of persons occupationally exposed to chromium, nickel, manganese and polycilic aromatic hydrocarbons. Acta. Medica. (Hardec Kravlove) suppl 1999; 42: 65-9.*
6. *Fidan F, Ünlü M, Köken T, Tetik L, Akgün S, Demirel R, Serteser M. Oxidant-Antioxidant Status and Pulmonary Function in Welding Workers. J Occup Health 2005; 47: 286-92.*
7. *Delk K, Gevirtz R, hicks D. The effects of biofeedback assisted breathing retraining on lung function in patients with cystic fibrosis. Chest 1993; 105: 23-8.*
8. *David M, Artene M, Duggan K. Physical activity in urban school aged children with asthma. Thorax 2004; 58:674-9, 2004.*
9. *Laakso L, Richardson C, Cramand T. Factors affecting low level laser therapy. Aust J Physiother 1993; 39: 95-9.*
10. *Lucas S, Platts-Mills T. Physical activity and exercise in asthma: Relevance to etiology and treatment. J Allergy Clin Immunol 2005; 115:928-34.*
11. *Jayasuriya A. Acupuncture "The Fourteen Channels" New York.1st ed. 1982: 21-43.*
12. *Irwin S, Tecklin J. Cardiopulmonary physical therapy, Mosby Company 4th ed. 2004: 309-10.*
13. *Geddesa E, Reidb W, Crowea J, O'Brienc K, Brooksc D. Inspiratory muscle training in adults with chronic obstructive pulmonary disease: A systematic review. Respir Med 2005; 99: 1440-58.*

14. Pardy R, Reid W, Belman M. Respiratory muscle training. Clin. Chest Med 1988; 9: 287-96.

15. Kellett C, Mullan J. Breathing Control techniques in the management of asthma. Physiotherapy 2002; 88:751-8.

16. Weiner P, Yanay B, Dacidocich A, Magadle R. Specific inspiratory muscle training in patients with mild asthma. Chest 2000; 117:722-7.

17. Ram F, Robinson S, Blach P. Effects of physical training in asthma. A systemic overview. Br J Sports Med 2000; 34:162-7.

18. Cambach W, Wagenar R, Koelman T. The long term effects of pulmonary rehabilitation in patients with asthma and chronic obstructive pulmonary disease. Arch Phys Med Rehab 1999; 80: 103-11.

19. Neder J, Nery L, Silva A, Cabral A. Short term effects of aerobic training in the clinical management of moderate to severe asthma in children. Thorax 1999; 54:202-6.

20. Chernyshova L, Khan M, Reutova V, Semenova U. The effect of low energy laser radiation in the infrared spectrum on bronchial patency in children with bronchial asthma. Vopr-Kurortol-Fizioter-lech-Fiz-Kult 1995; 2:11-4.

21. Shesterina MV, Selitskaia RP, Putilina LP, Ponomareva lulu. Effect of laser therapy on immunity of patients with bronchial asthma and pulmonary tuberculosis. Probl Tuberk 1994; 5:23-6.