Abstract

Background: 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.

Objective: The aim of this study was to compare two types of treatment protocols to determine small airway ventilation response to aerobic exercise and inspiratory muscle training with or without low intensity laser therapy in metal arc welders.

Material and Methods: Thirty metal arc welding workers who practiced welding job for no less than ten years were enrolled in this study their age ranged from 20 to 30 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.

Results: This study indicates that there is a significant improvement in measures of small airway ventilation in both groups. There were significant differences between both groups.

Conclusion: 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: Pulmonary rehabilitation – Aerobic exercise training – Inspiratory muscle training – Laser acupuncture therapy – Small airway ventilation – Arc welding.

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 (FEV1) /forced vital capacity (FVC) and four parameters of forced expiratory flow (FEF25%, FEF50%, FEF75%, FEF25-75%) 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 [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 is to compare the two types of treatment protocols in order to determine the small airway ventilation response to aerobic exercise and inspiratory muscle training with or without low-intensity laser therapy in metal arc welders.

Material and Methods

Thirty metal arc welders who practiced welding job for no less than ten years were enrolled in this study their age ranged from 20 to 35 years and were included in two equal groups. The first group (A) received aerobic exercise and inspiratory muscle training with laser acupuncture therapy for the respiratory system. The second group (B) received aerobic exercise and inspiratory muscle training. The program includes 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 according to the data of all the participants were statistically evaluated.

Evaluated parameters:

Small airway ventilation was measured using spirometer (Schiller Spiriovit Sp-10, Switzerland) 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 ST performed according to a modified Bruce protocol. 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 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 PTY LTD, 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 90º flexion and feet rest on the floor. 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), shuamzhong (Ren 17), Tianhu (Ren 22), feishu (U.B.B), Dazhui (Du 14), lieque (L.7) and Heagu (L.I.4) [11] Fig. (1: A, B, C, D).

Inspiratory muscle training:

Inspiratory muscle training was applied in the form of diaphragmatic breathing exercise. 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 0.2-1.2%), forced expiratory flow at 25-75% of forced vital capacity (FEF 25-75%), 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%) obtained before and after two months in both groups were evaluated by paired "t" test and Independent "t" test was used for the comparison between the two groups (p<0.05).

Results

Thirty metal arc welding workers were enrolled in this study their age ranged from 20 to 30 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.

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 (Tables 1,2 and Figs. 2,3). There were statistically significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment (Table 3 and Fig. 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.
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the mean FEF
welders. The results of this study indicated that the two types of treatment protocols to determine MEF
MEF
FEF
MEF
Table (1): Mean, standard deviation and significance of FEF_{0.2-1.2\%}, FEF_{25-75\%}, FEF_{75-85\%}, MEF_{50\%} and MEF_{50\%} in group (A) before and after treatment.

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

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_{50\%} = Maximum expiratory flow at 50% of forced vital capacity.

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.

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

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.

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.

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

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.

**Discussion**

The aim of this study was to compare between the two types of treatment protocols to determine small airway ventilation response to aerobic exercise training and inspiratory muscle training with or without low intensity laser 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. 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 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 it’s 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.

Conclusion:

Laser acupuncture therapy should significant influence in the aerobic exercise training and inspiratory muscle training improves small airway ventilation in metal arc welders.

Acknowledgment:

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