The Effect of High-Intensity Aerobic Exercise on the Pulmonary Function among Inactive Male Individuals

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A spirometer is an important instrument in the assessment of the lung functions. FVC, FEV1, MVV and ratio of FEV1/FVC are indicators of strong respiratory function that deteriorate due to a sedentary lifestyle. Prolonged aerobic exercises are thought to improve aerobic capacity and to have a favorable effect on lung function. Thus, the main aim of this study was to investigate the effect of such aerobic exercise for three weeks, specifically continuous treadmill running, on lung function (FVC, FEV1, ratio of FEV1/FVC, and MVV) in inactive yet healthy male individuals. For this study, 72 inactive male individuals were given a pulmonary function test. The test was performed three times for each session (starting with five minutes and increasing by ten minutes every three sessions, up to a maximum of 25 minutes), and its mean value was used for analysis. Exercise was performed three days a week for three weeks. The Wilcoxon test was done to determine changes pre- to post-test. Repeated-measure analyses were used to compare the changes of pulmonary values between high-intensity sessions. Spearman correlation r was conducted to assess association between MVV, FVC, and FEV1, and the Friedman test was used to compare the mean ratio of FEV1/FVC before and after exercise of different intensities. FEV1, MVV and a ratio of FEV1/FVC were significantly improved after high-intensity aerobic exercise of different intensities. In addition positive relation of MVV with FEV1 improvements was found. In contrast, there were insignificant improvements in FVC before and after exercise of different intensities and with no positive relation of MVV improvements. The improvements in MVV could reflect subtle changes in lung function or airway reactivity not detected by the FVC test. In addition, higher exercise intensity or longer duration may be needed to affect other lung function parameters like MVV, FEV1 and FEV1/FVC. Thus our results demonstrate that high-intensity aerobic exercise on the treadmill has a positive effect on the pulmonary function of inactive healthy subjects.

Keywords: Pulmonary function, High-intensity aerobic exercise, FVC, FEV1, MVV.
of lung function, as they decline noticeably due to sedentary lifestyle1-3.

In one study, 6790 subjects were followed for 19 months. Those with active lifestyles showed an improvement of 50 ml in FEV1 and 70 ml in FVC; however, subjects with sedentary lifestyles experienced a 30 ml reduction in FEV1 and 20 ml reduction in FVC4. Moreover, other studies have shown that physical activity can improve lung function dramatically in subjects with diseases like asthma and in children with intellectual disabilities5-6. These findings suggest that a sedentary lifestyle can cause the deterioration of respiratory indices and might put one at high risk for developing chronic obstructive pulmonary disease. Appropriate interventions such as physical activity programs, however, may prevent such deterioration.

Other recent studies have investigated the effect of exercise on pulmonary function. For example, dancing7, playing gate ball8, and exercising core muscles9 were reported to have had a positive effect on pulmonary function in the elderly. The results of such studies have led to increasing interest in exercise programs that can improve pulmonary function and prevent respiratory disease.

Although there have been many studies that show aerobic exercises extensively improves the endurance and strength of respiratory muscles, decreases resistance and increase lung elasticity and alveolar expansion by promoting the expansion of pulmonary volumes and capacities, others have found that it has no significant effect10.

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Prolonged aerobic exercises are thought to improve aerobic capacity and to have a favorable effect on lung function. Thus, the main aim of this study was to investigate the effect of such aerobic exercise for three weeks, specifically continuous treadmill running, on lung function (FVC, FEV1, ratio of FEV1/FVC, and MVV) in inactive yet healthy male individuals.

**METHODS**

**Sample size**

For this study, 72 male subjects were recruited.

**Study population**

Subjects (aged 18–50 years) were recruited. Informed consent was taken from each after they had been given a detailed explanation of the experiment. The subjects were asked to complete questionnaires on medical history to ensure they are in a good health (no acute illnesses related to respiratory or heart disease).

**Sampling method and study design**

Pre-test/post-test studies measure the change in a situation. They are often used to measure the efficacy of an intervention and can be considered comparative cross-sectional. For this study, 72 male subjects were randomly selected by simple random sampling technique (SRS).

**Sources and methods of data collection**

Measurements of respiratory indices were taken three times in the pre- and post-exercise phases of each session, and their mean values were used for analysis. Subjects were asked not to change their habitual physical activity during the study and not to take any nutritional supplements.

**Inclusion criteria**

Subjects recruited for this study had to meet the criteria listed below:
1. Age 18 or older
2. In good health (no acute illnesses related to respiratory or heart disease)
3. Cooperative

**Protocol**

The high-intensity exercise training program consisted of continuous treadmill running (grade = 0%) three days a week for three weeks. Each session began with a warmup period of five minutes. For the session itself, running time started at five minutes, and this interval was increased by ten minutes every three sessions, up to a maximum of 25 minutes. The speed of running was adjusted according to the target heart rate zone (75–85% HR max).

**Measurements**

Pulmonary function tests were carried out by SPIROVIT SP-1 spirometer to determine FVC, FEV1, FEV1/FVC, and MVV. Subjects had
to remain in the straight sitting or standing position throughout the test, and a nose clip was tightly attached to the nostrils, allowing no air to escape during the test. A mouthpiece was placed at least two centimeters into the subject’s mouth, with lips closed around it.

FVC Maneuver: Each subject was asked to inhale completely and rapidly, pausing less than one second at total lung capacity (TLC), and then exhale as quickly and completely as possible, expelling all the air. Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and forced expiratory volume in the first second/forced vital capacity (FEV1/FVC) were obtained and recorded by the apparatus.

MVV maneuver: Subjects were tested in the sitting position while wearing a nose clip. They were instructed to breathe as rapidly and deeply as possible for 12 seconds after obtaining at least three resting tidal breaths with an airtight seal around the mouthpiece.

Statistical analysis
The values are reported as mean ± standard deviations. Statistical analysis was conducted using SPSS software version 16. The Wilcoxon test, a nonparametric analysis (paired t-test), was done to determine changes pre- to post-test. Repeated-measure analyses were used to compare the changes of pulmonary values between high-intensity sessions. Spearman correlation rho was conducted to assess association between MVV, FVC, and FEV1, and the Friedman test was used to compare the mean ratio of FEV1/FVC before and after exercise of different intensities.

RESULTS
Table 1 shows the mean of the anthropometric characteristics of the 72 subjects. The mean age was 30.94 ± 11.29 years, the mean height was 172.65 ± 5.72 cm, and the mean weight was 79.67 ± 12.56 kg.

Table 2 shows the baseline spirometry data of predicted values for the 72 subjects. The mean predicted FVC was 4.00 ± 0.51 L, mean predicted FEV1 was 3.76 ± 0.55 L, and mean predicted MVV was 127.14 ± 22.44 L.

Table 3(A) shows the baseline spirometry data of FVC and FEV1 pre- and post-exercise at different intensities. The mean pre-exercise FVC was 3.80 ± 0.71 L, and the mean pre-exercise FEV1 was 3.37 ± 0.77 L. Post-exercise mean FVC after 5, 15, and 25 minutes was 3.92 ± 0.56 L, 3.92 ± 0.70 L, and 3.96 ± 0.48 L respectively. The post-exercise mean FEV1 after 5, 15, and 25 minutes was 3.73 ± 0.62 L, 3.86 ± 0.49 L, and 3.93 ± 0.53 L respectively (the trend here is obvious).

Table 3(B) shows the baseline spirometry data of MVV before and after exercise at different intensities. The pre-exercise mean MVV was 125.47 ± 32.97 L, the post-exercise mean MVV after 5, 15, and 25 minutes was 134.26 ± 30.21 L, 135.54 ± 53.18 L, and 143.95 ± 31.34 L respectively, and the post-exercise means of FVC, FEV1, and MVV for all intensities were 3.94 ± 0.30 L, 3.84 ± 0.34 L, and 137.92 ± 21.53 L respectively. The improvement here is obvious when compared to pre-mean values for all lung functions (FVC, FEV1, and MVV).

The FEV1/FVC ratios before and after exercise at different intensities were measured by the Friedman test, which showed that the pre-exercise FEV1/FVC ratio is significantly lower than the post-exercise mean of the FEV1/FVC ratio with p-value < 0.001.

Table 4 shows the paired t-test. The means of pre-exercise FEV1 and MVV were significantly lower than the post-exercise means, with p < 0.001 and p = 0.003, respectively. However, the mean of FVC showed no significant difference before or after exercise, with p = 0.241.

Post-exercise means at different intensities of FEV1 and MVV were significantly higher than pre-mean values, with p < 0.001 and 0.039 respectively. However, FVC showed no significant difference between pre- and post-exercise means at different intensities (p = 0.444) (Table 5).

Table 6 shows that the post-exercise FEV1 improvements were positively and significantly associated with MVV improvement. However, pre-exercise improvements in FVC are not associated with MVV improvement.

DISCUSSION
Many studies have recommended treadmill aerobic exercise as a way to maintain or improve pulmonary function11-12.

A spirometer is an important instrument in the assessment of the lung functions. FVC, FEV1,
MVV and ratio of FEV1/FVC are indicators of strong respiratory function that deteriorate due to a sedentary lifestyle.

Prolonged aerobic exercises are thought to improve aerobic capacity and to have a favorable effect on lung function. Thus, the main aim of this study was to investigate the effect of such aerobic exercise for three weeks, specifically continuous treadmill running, on lung function (FVC, FEV1, ratio of FEV1/FVC, and MVV) in inactive yet healthy male individuals.

Therefore, in this study, we investigated the effect of three weeks of continuous treadmill running on FVC, FEV1, FEV1/FVC, and MVV values for 72 inactive yet healthy male individuals.

FEV1 and MVV significantly improved after high-intensity aerobic exercise. In contrast, there were insignificant improvements in FVC. The improvement in FEV1 means that high-intensity aerobic exercise improves air flow in the respiratory tract. This finding is consistent with other studies, which postulated that FEV1 improvement is mainly caused because the lungs expand during high-intensity aerobic exercise, resulting in a larger volume of air introduced into the airways and a widening of the respiratory tract.

MVV is the measure of respiratory muscle performance. Positive relation of MVV improvement with FEV1 improvements showed that the respiratory muscle performance enhancement due to aerobic exercise can improve lung function. This is consistent with a previous study by Miyahara et al., in which MVV improved significantly in 18 COPD patients following a three-week cycle ergo-meter exercise training program. Similarly, MVV improved significantly in 40 COPD patients after a nine-week program of aerobic and upper-body exercise, and in asthmatic subjects after a 36-session aerobic exercise program.

### Table 1. Anthropometric characteristics (m ± SD) of total subjects

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>30.94</td>
<td>172.65</td>
</tr>
<tr>
<td>Std. Deviation (SD)</td>
<td>11.29</td>
<td>5.72</td>
</tr>
</tbody>
</table>

### Table 2. Baseline spirometric data (m ± SD) of predicted values

<table>
<thead>
<tr>
<th>pred FVC (L)</th>
<th>pred FEV1 (L)</th>
<th>pred MVV (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.00</td>
<td>3.76</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.51</td>
<td>0.55</td>
</tr>
</tbody>
</table>

### Table 3(A). Baseline spirometric data (m ± SD) of FVC and FEV1 before and after exercise at different intensities

<table>
<thead>
<tr>
<th>Pre exercise FVC</th>
<th>5 min post exercise FVC</th>
<th>15 min post exercise FVC</th>
<th>25 min post exercise FVC</th>
<th>Pre exercise FEV1</th>
<th>5 min post exercise FEV1</th>
<th>15 min post exercise FEV1</th>
<th>25 min post exercise FEV1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.80</td>
<td>3.92</td>
<td>3.92</td>
<td>3.96</td>
<td>3.77</td>
<td>3.73</td>
<td>3.86</td>
</tr>
<tr>
<td>SD</td>
<td>0.71</td>
<td>0.56</td>
<td>0.70</td>
<td>0.48</td>
<td>0.77</td>
<td>0.62</td>
<td>0.49</td>
</tr>
</tbody>
</table>

### Table 3(B). Baseline spirometric data (m ± SD) of MVV before and after exercise at different intensities

<table>
<thead>
<tr>
<th>Pre exercise MVV</th>
<th>5 min post exercise MVV</th>
<th>15 min post exercise MVV</th>
<th>25 min post exercise MVV</th>
<th>FVC-Post exercise</th>
<th>FEV1-Post exercise</th>
<th>MVV-Post exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>125.47</td>
<td>134.26</td>
<td>135.54</td>
<td>143.95</td>
<td>3.94</td>
<td>3.84</td>
</tr>
<tr>
<td>SD</td>
<td>32.97</td>
<td>30.21</td>
<td>53.18</td>
<td>31.34</td>
<td>0.30</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Improvement in MVV after exercise training could be due to increased development of respiratory musculature incidental to physical training\textsuperscript{16} or to decreased release of inflammatory mediators in patients with bronchial asthma\textsuperscript{17}. However, if the mechanism is an increase in respiratory muscle force production, this may explain why MVV improved significantly in the present study while FVC showed no significant increase. The increase in MVV with no improvement in FVC suggests a training effect on the respiratory muscles without an improvement in large or small airways, as MVV is less affected by the state of airways than other parameters.

Moreover, the improvement in MVV could reflect subtle changes in lung function or airway reactivity not detected by the FVC test. In addition, higher exercise intensity or longer duration may be needed to affect other lung function parameters like MVV\textsuperscript{18}.

What supports this idea in our study that we recruited healthy inactive subjects who values of pre FVC, FEV1 and MVV values were lower compared to predicted values results of respiratory muscle weakness due to sedentary lifestyle. This finding is consistent with Simões et al.\textsuperscript{19} who found that respiratory muscle strength was significantly lower in individuals with sedentary lifestyles. Thus, such subjects have needed greater training intensity or longer exercise duration to affect their pulmonary systems and get more significant results. Also, improvement in MVV could be due to improvement in the compliance of the lung-thorax system after exercise training that mainly affects MVV\textsuperscript{20}.

Many studies have shown that FVC is significantly improved after high-intensity aerobic exercise\textsuperscript{21-22}. This means that the vital capacity also increased. It has been suggested that high-intensity aerobic exercise would increase VO2 max and activated inactive alveoli. Moreover, repeated stimulation of inspiration and expiration would increase alveolar compliance. As a result, FVC would increase. In addition, many studies have investigated the effect of exercise on FEV1/FVC and suggested that the enhancement of respiratory muscles and trunk muscles and the improvement

### Table 4. Lung function indices before and after exercise (paired t-test)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre exercise</th>
<th>Post exercise</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC(L)</td>
<td>3.80±0.71</td>
<td>3.94±0.30</td>
<td>0.241</td>
</tr>
<tr>
<td>FEV(L)</td>
<td>3.37±0.77</td>
<td>3.84±0.34</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>MVV(L)</td>
<td>125.47±32.97</td>
<td>137.92±21.53</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

*Significantly different before and after exercise (p < 0.05). FVC: forced expiratory volume. FEV1: forced expiratory volume in one second. MVV: maximum voluntary ventilation.

### Table 5. ANOVA of lung function before and after exercise at different intensities

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre exercise</th>
<th>Post exercise 5min</th>
<th>Post exercise 15min</th>
<th>Post exercise 25min</th>
<th>F-test</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC(L)</td>
<td>3.80</td>
<td>3.92</td>
<td>3.93</td>
<td>3.96</td>
<td>0.895</td>
<td>0.444</td>
</tr>
<tr>
<td>FEV(L)</td>
<td>3.37</td>
<td>3.73</td>
<td>3.86</td>
<td>3.93</td>
<td>12.044</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>MVV(L)</td>
<td>125.47</td>
<td>134.26</td>
<td>135.54</td>
<td>143.95</td>
<td>2.834</td>
<td>0.039*</td>
</tr>
</tbody>
</table>

*Significantly different before and after exercise at different intensities (p < 0.05). FVC: forced expiratory volume. FEV1: forced expiratory volume in one second. MVV: maximum voluntary ventilation.

### Table 6. Associations of MVV changes with FVC and FEV1 improvements before and after exercise

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>0.140</td>
<td>0.038</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.239</td>
<td>0.751</td>
</tr>
<tr>
<td>FEV1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.104</td>
<td>-0.307</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.384</td>
<td>0.009**</td>
</tr>
</tbody>
</table>

**Significant at p < 0.01.
of rib cage movement had a positive effect\textsuperscript{23-24-25}. In one study, very young competitive female swimmers were found to have an increase in their vital capacity and total lung capacity during one year of training, suggesting that larger lung volumes in swimmers may be due to training. Although the mechanism by which physical inactivity might influence FVC and FEV1 is unclear, the relationship between muscular force and FVC and FEV1 is established\textsuperscript{26}. In this study, FEV1/FVC seemed to increase significantly after exercise. This result suggests that the exercise used in our study was not a muscle-strengthening or rib-cage-expanding exercise, but one directly stimulating alveoli with high-intensity aerobic exercise. This may explain the significant improvements in MVV and FEV1 but not FVC.

However, the results of pulmonary functions in our study cannot be compared directly with previous research mainly due to the different method and sample size used, as well as differences in the investigated subjects’ age and sex. Thus, more research is needed to investigate and confirm this study’s findings.

**CONCLUSION**

This study examines whether high-intensity aerobic exercise on a treadmill is effective in improving pulmonary function among 72 healthy inactive male individuals. A significant improvement after exercise was observed in FVC, FEV1, MVV, and FEV1/FVC. The results demonstrate that high-intensity aerobic exercise on the treadmill has a positive effect on the pulmonary function of inactive healthy subjects.

In conclusion, Aerobic exercise training should be included in plans to decrease sedentary behavior, improve aerobic capacity, and improve or at least maintain lung function in sedentary subjects. Our data suggest that a much longer exercise intervention or more exercise intensity may be needed to significantly improve lung function in inactive subjects.

**REFERENCES**


