Effects of Eight-Week Resistance Training on the Quality of Life and Sleep Quality of Untrained Men with a History of COVID-19

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Abstract

**Background** The COVID-19 pandemic has caused physical, psychological, and functional complications in society, with particular impacts on positive cases. Reduced quality of life (QOL) and sleep quality are among the many problems experienced by COVID-19 patients. Hence, exercise rehabilitation gains further importance after people are afflicted with COVID-19. This study aimed to analyze the effects of resistance training on the QOL and sleep quality in untrained men with a history of COVID-19.

**Methods** Based on inclusion and exclusion criteria, purposive sampling was employed to select 34 individuals who were willing to participate in the study. They were then randomly assigned to a resistance training group and a control group (n=17 per group). In order to evaluate the pretest scores of sleep quality and those of QOL, the participants were asked to complete the Pittsburgh Sleep Quality Index (PSQI) and the Short Form 36 Health Survey Questionnaire (SF-36), respectively. Subsequently, the training group received eight weeks of resistance training held three sessions weekly. The participants re-completed the foregoing questionnaires when all training sessions were over to determine their posttest scores. The resultant data were then analyzed in SPSS 27.

**Results** The research findings indicated significant differences between the resistance training group and the control group regarding the QOL and sleep quality after eight weeks of resistance training (P ≤ 0.05).

**Conclusions** Given the findings of the current study, one can conclude that resistance training has positive effects on the QOL and sleep quality in untrained men with a history of COVID-19. Hence, resistance training can probably be recommended to rehabilitate patients with COVID-19.

**Trial registration number** IRCT20230221057480N1, 2023-03-04, retrospectively registered.

Background

In 2019, a novel coronavirus pathogen was identified in Wuhan, China, which spread rapidly worldwide. This virus was first found in seafood products in China. The World Health Organization (WHO) recognized the virus as COVID-19 (1, 2). According to the statistics, nearly 685 million people have contracted the virus worldwide since the pandemic broke out. Moreover, approximately 6.8 million people passed away due to the disease (3). Studies (4, 5) report the high fatality rate of this disease, indicating that long-lasting psychological disorders, nervous complications, cardiovascular problems, respiratory problems, and muscular-skeletal difficulties caused by COVID-19 will affect patients for a long time, even after the initial recovery. These complications are referred to as post-COVID or long COVID syndrome, the prominent symptoms of which include sleep disorders reducing the quality of life (QOL).

Neurologists analyzing sleep disorders have reported a growing prevalence of COVID-19-associated sleep disorders. Referred to as COVID-somnia, these disorders include insomnia, hypersomnia, night terror, and misuse of sleeping pills (6). Sleep quality is an important indicator of health. In fact, a good level of sleep quality can improve the immune system against viral infections (7). It can also help enhance learning and
memory (8). According to different studies (9, 10), sleep plays a key role in the QOL from the early days of childhood, and lack of sleep can have devastating effects on both physical and mental health.

QOL, on the other hand, is considered a very important indicator of health. Hence, it is essential to pay attention to different dimensions of QOL, such as physical health, mental health, social relations, familial life, physical functions, emotions, and spirituality (11). Considering the long-lasting disorders caused by COVID-19, researchers are trying to find the best method of rehabilitating patients and alleviating post-COVID syndrome disorders.

According to a literature review (12, 13), physical activity and exercise can be prescribed along with other treatments to help individuals cope with many pathogens during or after a disease. When the early symptoms of COVID-19 emerged, many sports researchers tried to highlight the previously known role of this inexpensive therapy (i.e., exercise) in improving patients. Although many people resorted to pharmacotherapy to enhance the quality of their sleep (14), other studies (15, 16) indicated that sports exercises could boost the sleep quality.

Silva-Batista et al. (17) reported the significant effects of 12 weeks of resistance training on improved sleep quality among 22 patients with Parkinson's disease. In another study, Andreu-Caravaca et al. (18) reported that ten weeks of resistance training in patients with multiple sclerosis (MS) enhanced the sleep quality and mitigated sleep disorders. Moreover, some studies analyzed the effects of sports exercises on the QOL among COVID-19 patients. For instance, Dalbosco-Salas et al. (19) evaluated the effects of nine weeks of sports exercises on 115 individuals who had contracted COVID-19. Their results indicated that nine weeks of aerobic exercise improved their QOL. In addition, Nambi et al. (20) highlighted the effects of eight weeks of resistance training and aerobic exercises on the QOL of individuals who had contracted COVID-19.

Although different studies have addressed the rehabilitation of patients with COVID-19, there are still insufficient research studies focusing on the subject, which is suggestive of a research gap. Many studies (21, 22) have analyzed the effects of exercise rehabilitation on COVID-19 patients during or after the disease. They have all emphasized improved performance and alleviated symptoms after the implementation of exercise rehabilitation. However, the researcher believes there are apparently no studies regarding the effect of resistance training on sleep quality among individuals with a history of COVID-19.

Known as one of the many sports exercises improving QOL and sleep quality, resistance training has been proven to have a major role in people's health and improvement (23). Westcott et al. (24) reported that resistance training would reverse muscle loss, recharge resting metabolism, reduce body fat, improve blood lipid profiles, boost cardiovascular health, enhance mental health, increase bone mineral density, and reverse aging factors. Hence, resistance training can be useful in rehabilitating patients with COVID-19. Moreover, many other studies (17, 18, 25) have reported the positive effects of resistance training on QOL and sleep quality among patients with sleep disorders. Accordingly, resistance training was employed in this study to evaluate the effects of sports exercises on QOL and sleep quality in people who
had contracted COVID-19. Furthermore, Gentil et al. (26) reported the safety of resistance training and its positive effects on individuals with a history of COVID-19. Therefore, it is safe for such people to do resistance training if they follow care protocols.

This being said, how can eight weeks of resistance training affect the QOL and sleep quality in untrained men with a history of COVID-19? This question is addressed below.

**Methods**

This quasi-experimental developmental research included an experimental group and a control group. The research period was from May to July 2022. Before the executive procedure commenced, the research protocol was approved by the specialized ethics committee of biomedical studies at the University of Tehran (Ethics Code: IR.UT.SPORT.REC.1401.005).

Given the highly probable prevalence of sleep disorders in individuals who had contracted COVID-19, the statistical population of this study included untrained men with sleep disorders in Tehran. Other criteria comprised a diagnosis of COVID-19 at least 12 weeks prior to the study and a lack of resistance training exercises six months before the intervention.

**Research Procedure**

After participation invitations were sent via email and social media, 90 individuals from the target population announced their willingness to participate. They were evaluated, and 34 individuals aged 18–30 years old were selected purposively in accordance with the inclusion and exclusion criteria. They were subsequently randomly assigned to a control group and a resistance training group (n=17 per group).

The inclusion criteria were as follows: being male, being aged 18–30 years old, having a body mass index (BMI) of 18-30, having no experience of resistance training within the past six months (27), contracting the COVID-19 twelve weeks before the intervention or earlier (4), being diagnosed as a mild to moderate case of the COVID-19 (28), and obtaining a total score of five or higher on the Pittsburgh Sleep Quality Index (PSQI) (29). The exclusion criteria were as follows: having a resting heart rate of above 100 beats per minute, having a blood pressure of below 90.60 mmHg, having a blood pressure of above 140.90 mmHg, having a blood oxygen saturation level of below 95% (30), taking sleep affecting drugs, smoking (31), and leaving the training protocol.

After the eligible participants were identified, they completed demographic forms, the PSQI, the SF-36, and consent forms. Afterward, a specialist examined all participants medically to confirm their participation in the study. Initially, the participation steps were explained completely to the participants. They were then instructed separately and accurately in the research training protocol movements. During the protocol, the participants were constantly in touch with the researcher for monitoring purposes. At the end of the eighth week, the PSQI and the SF-36 were re-completed by the participants from both groups. The results were then prepared for statistical analysis. Two control cases were excluded from the study during the
eight-week training protocol due to the use of sleeping pills. Figure 1 demonstrates the flowchart of the study briefly.

**Training Protocol**

The National Academy of Sports Medicine (NASM) guidelines on strength training and bodybuilding were employed to design the exercises (32). In the training protocol, participants first used a stationary bicycle for five minutes at a medium speed and a low resistance for warm-up. Afterward, they performed dynamic stretching for the entire body. When the warm-up was completed, they followed the steps presented in Table 1. Once done with the major moves, the participants used a stationary bicycle again for three minutes at a low speed but without resistance for cool-down. Finally, they performed static stretching for all their active muscles. The exercises were performed three times weekly over the course of eight weeks. The training load increased by 5–10% every week.

**Table 1. Training Protocol**

<table>
<thead>
<tr>
<th>1RM</th>
<th>one-repetition maximum</th>
</tr>
</thead>
</table>

**Pittsburgh Sleep Quality Index (PSQI)**

The PSQI is among the best tools designed to evaluate sleep quality. The PSQI was developed by Buysse et al. at Pittsburgh Psychoanalytic Center in 1989. Basically, this index consists of 9 items; however, the fifth item includes ten sub-items. Hence, the entire index has 19 items scored on a four-point Likert scale ranging from 0 to 3. Generally, this questionnaire consists of seven indices: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medications, and daytime dysfunction (29).

**Short Form 36 Health Survey Questionnaire (SF-36)**

Ware and Sherbourne designed this questionnaire in the United States in 1992. Its reliability and validity were analyzed in different groups of patients. The concepts evaluated by this questionnaire would not depend on a specific age, group, or disease. In fact, this questionnaire is administered to evaluate both physical health and mental health by integrating the scores of eight dimensions of health. The 36 items of this questionnaire assess eight dimensions of health: physical functioning, role limitations due to physical health, pain, general health, vitality, social functioning, role limitations due to emotional problems, and emotional well-being. The total score of QOL ranges from 0 to 100. The higher the total score, the higher the QOL (33).

**Sample Size**

The sample size was considered at least 34 participants in G*Power 3.1 (34), given a confidence coefficient of 0.95, an effect size of 0.50, and a test power of 0.8.

**Statistical Analysis**
### Warm-up

<table>
<thead>
<tr>
<th>Training type</th>
<th>Set</th>
<th>Duration/reps</th>
<th>Practice tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary bicycle</td>
<td>1</td>
<td>5 min</td>
<td>Medium speed, low resistance</td>
</tr>
<tr>
<td>Dynamic stretching for the entire body</td>
<td>2</td>
<td>10 reps</td>
<td>Stretch each part for 2 sec</td>
</tr>
</tbody>
</table>

### Resistance training

<table>
<thead>
<tr>
<th>Training type</th>
<th>Set</th>
<th>Reps</th>
<th>Tempo (sec)</th>
<th>Rest (sec)</th>
<th>Load (% 1RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbell shoulder press</td>
<td>3</td>
<td>12</td>
<td>2-1-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Barbell bicep curl</td>
<td>3</td>
<td>12</td>
<td>2-0-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Hack squat</td>
<td>3</td>
<td>12</td>
<td>3-0-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Lying barbell triceps extension</td>
<td>3</td>
<td>12</td>
<td>2-0-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Lat pulldown machine</td>
<td>3</td>
<td>12</td>
<td>2-1-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Barbell bench press</td>
<td>3</td>
<td>12</td>
<td>2-0-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Leg extension machine</td>
<td>3</td>
<td>12</td>
<td>2-1-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Dumbbell shrugs</td>
<td>3</td>
<td>12</td>
<td>2-1-2</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Forearm plank</td>
<td>3</td>
<td>45 (sec)</td>
<td></td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

### Cool-down

<table>
<thead>
<tr>
<th>Training type</th>
<th>Set</th>
<th>Duration</th>
<th>Practice tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary bicycle</td>
<td>1</td>
<td>3 min</td>
<td>Low speed, without resistance</td>
</tr>
<tr>
<td>Static stretching for all active muscles</td>
<td>2</td>
<td>10 sec</td>
<td>Stretch each muscle for 10 sec</td>
</tr>
</tbody>
</table>

The raw data obtained from the measurement of research variables were analyzed in SPSS 27. In terms of descriptive statistics, the means and standard deviations of all variables were calculated. The Shapiro-Wilk test was employed to determine the normal distribution of data. Moreover, the nonparametric Mann-Whitney U test was adopted to compare the results of the two groups in terms of sleep quality, whereas the nonparametric Wilcoxon test was utilized to draw within-group comparisons. Additionally, the nonparametric Mann-Whitney U test was employed to compare the results of the two groups in the QOL with regard to physical functioning, role limitations due to physical health, pain, social functioning, and role limitations due to emotional problems. The nonparametric Wilcoxon test was used for a within-group comparison. In addition, the parametric independent t-test was utilized to compare the results of the two
groups in terms of general health, vitality, emotional well-being, and the total score of the QOL, whereas the parametric paired t-test was used for within-group comparisons.

## Results

Table 2 reports the demographics and results of medical tests pertaining to the participants before the study was conducted. According to this table, there were no significant differences between the resistance training group and the control group regarding the research variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Training (n = 17) M (SD)</th>
<th>Control (n = 15) M (SD)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>25.1 ± 3.6</td>
<td>25.4 ± 3.0</td>
<td>0.81</td>
</tr>
<tr>
<td>Height, cm</td>
<td>178.0 ± 6.0</td>
<td>178.8 ± 5.2</td>
<td>0.67</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>79.0 ± 8.9</td>
<td>81.8 ± 5.9</td>
<td>0.31</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>24.9 ± 2.6</td>
<td>25.6 ± 2.5</td>
<td>0.44</td>
</tr>
<tr>
<td>Resting heart rate, bpm</td>
<td>68.7 ± 1.7</td>
<td>67.8 ± 1.9</td>
<td>0.71</td>
</tr>
<tr>
<td>Systolic blood pressure, mmHg</td>
<td>125.8 ± 13.9</td>
<td>126.15 ± 90.7</td>
<td>0.75</td>
</tr>
<tr>
<td>Diastolic blood pressure, mmHg</td>
<td>82.9 ± 38.6</td>
<td>82.1 ± 60.7</td>
<td>0.81</td>
</tr>
<tr>
<td>Blood oxygen saturation, %</td>
<td>95.4 ± 2.3</td>
<td>95.6 ± 3.4</td>
<td>0.52</td>
</tr>
<tr>
<td>The time elapsed since the initial infection with COVID-19, month</td>
<td>6.0 ± 1.50</td>
<td>5.13 ± 1.24</td>
<td>0.08</td>
</tr>
</tbody>
</table>

### Severity of COVID-19

<table>
<thead>
<tr>
<th>Severity of COVID-19</th>
<th>Training (n)</th>
<th>Control (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild severity (n = 18)</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Moderate severity (n = 14)</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

**BMI** body mass index, *M(SD)* mean ± standard deviation

Table 3 reports some information about the means and standard deviations of pretest and posttest scores on the sleep quality indices. After eight weeks, all the sleep quality indices improved significantly in the resistance training group after eight weeks (*P* ≤ 0.05). The results also indicated significant differences between posttest scores and pretest scores of all sleep quality indices in the resistance training group: subjective sleep quality (0.001), sleep latency (0.002), sleep duration (0.001), sleep efficiency (0.041), sleep disturbance (0.008), daytime dysfunction (0.004), and total PSQI score (0.001).
Table 3
Results of the Wilcoxon test to analyze within-group differences in sleep quality in study groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>Pretest M (SD)</th>
<th>Posttest M (SD)</th>
<th>Z</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective sleep quality</td>
<td>Resistance training</td>
<td>2.0 ± 0.6</td>
<td>0.7 ± 0.4</td>
<td>-3.78</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.3 ± 0.6</td>
<td>2.4 ± 0.6</td>
<td>-1.00</td>
<td>0.317</td>
</tr>
<tr>
<td>Sleep latency</td>
<td>Resistance training</td>
<td>1.6 ± 0.7</td>
<td>0.7 ± 0.4</td>
<td>-3.03</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.0 ± 0.5</td>
<td>2.1 ± 0.5</td>
<td>-0.44</td>
<td>0.655</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>Resistance training</td>
<td>1.4 ± 1.0</td>
<td>0.1 ± 0.3</td>
<td>-3.21</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.7 ± 0.7</td>
<td>0.7 ± 0.4</td>
<td>0.00</td>
<td>0.999</td>
</tr>
<tr>
<td>Sleep Efficiency</td>
<td>Resistance training</td>
<td>0.5 ± 1.0</td>
<td>0.0 ± 0.0</td>
<td>-2.04</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.2 ± 0.5</td>
<td>0.4 ± 0.6</td>
<td>-1.00</td>
<td>0.317</td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>Resistance training</td>
<td>1.4 ± 0.5</td>
<td>1.0 ± 0.0</td>
<td>-2.64</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.4 ± 0.5</td>
<td>1.4 ± 0.5</td>
<td>0.00</td>
<td>0.999</td>
</tr>
<tr>
<td>Daytime dysfunction</td>
<td>Resistance training</td>
<td>1.5 ± 0.7</td>
<td>0.8 ± 0.3</td>
<td>-2.91</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.6 ± 0.7</td>
<td>1.8 ± 0.6</td>
<td>-2.00</td>
<td>0.511</td>
</tr>
<tr>
<td>Total PSQI Score</td>
<td>Resistance training</td>
<td>8.6 ± 2.3</td>
<td>3.4 ± 1.0</td>
<td>-3.64</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>8.4 ± 2.0</td>
<td>9.0 ± 1.8</td>
<td>-1.49</td>
<td>0.134</td>
</tr>
</tbody>
</table>

*M(SD) mean ± standard deviation

Table 4 presents the Mann-Whitney U test results to analyze differences between the two groups concerning sleep quality. According to the results, the two groups had a significant difference in the total score of sleep quality in the posttest (P = 0.001). Indeed, there were significant differences between the groups in the posttest scores of all sleep quality indices.
**Table 4**

Results of the Mann-Whitney U test for analysis of between-group differences in sleep quality

<table>
<thead>
<tr>
<th>Variables</th>
<th>Time</th>
<th>Resistance training</th>
<th>Control</th>
<th>U</th>
<th>Z</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective sleep quality</td>
<td></td>
<td>14.4</td>
<td>9.3</td>
<td>18.8</td>
<td>24.6</td>
<td>-1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>92.5</td>
<td>6.0</td>
<td>-4.81</td>
</tr>
<tr>
<td>Sleep latency</td>
<td></td>
<td>13.9</td>
<td>9.3</td>
<td>19.4</td>
<td>24.5</td>
<td>-1.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84.0</td>
<td>6.5</td>
<td>-4.88</td>
</tr>
<tr>
<td>Sleep duration</td>
<td></td>
<td>19.3</td>
<td>12.3</td>
<td>13.2</td>
<td>21.2</td>
<td>-1.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78.5</td>
<td>56.5</td>
<td>-3.11</td>
</tr>
<tr>
<td>Sleep Efficiency</td>
<td></td>
<td>17.3</td>
<td>13.5</td>
<td>15.5</td>
<td>19.9</td>
<td>-0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>112.5</td>
<td>76.5</td>
<td>-2.83</td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td></td>
<td>16.5</td>
<td>13.5</td>
<td>16.4</td>
<td>19.9</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>126.0</td>
<td>76.5</td>
<td>-2.84</td>
</tr>
<tr>
<td>Daytime dysfunction</td>
<td></td>
<td>16.4</td>
<td>10.6</td>
<td>16.5</td>
<td>23.1</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>127.0</td>
<td>28.0</td>
<td>-4.20</td>
</tr>
<tr>
<td>Total PSQI Score</td>
<td></td>
<td>17.2</td>
<td>9.0</td>
<td>15.7</td>
<td>24.9</td>
<td>-0.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>115.5</td>
<td>1.0</td>
<td>-4.82</td>
</tr>
</tbody>
</table>

Tables 5 and 6 report the results of the Wilcoxon test and those of the paired t-test, respectively, to analyze the difference between the resistance training group and the control group in the QOL. According to the results, there were significant improvements in all QOL indices after the posttest in the resistance training group: physical functioning (0.001), role limitations due to physical health (0.001), pain (0.001), social functioning (0.001), role limitations due to emotional problems (0.001), general health (0.001), vitality (0.001), emotional well-being (0.001), and total SF-36 score (0.001). Moreover, the posttest scores of physical functioning (0.024), role limitations due to physical health (0.025), pain (0.042), and general health (0.029) decreased significantly in the control group.
Table 5
Results of the Wilcoxon test to analyze within-group differences in QOL in study groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>Pretest M (SD)</th>
<th>Posttest M (SD)</th>
<th>Z</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical functioning</td>
<td>Resistance training</td>
<td>81.4 ± 15.9</td>
<td>93.2 ± 9.9</td>
<td>-3.43</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>69.6 ± 18.4</td>
<td>65.0 ± 19.4</td>
<td>-2.26</td>
<td>0.024</td>
</tr>
<tr>
<td>Role limitations due to physical health</td>
<td>Resistance training</td>
<td>41.1 ± 40.4</td>
<td>86.7 ± 21.8</td>
<td>-3.37</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>36.6 ± 37.6</td>
<td>28.3 ± 33.8</td>
<td>-2.23</td>
<td>0.025</td>
</tr>
<tr>
<td>Pain</td>
<td>Resistance training</td>
<td>67.6 ± 26.0</td>
<td>82.5 ± 17.9</td>
<td>-3.24</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>60.0 ± 20.0</td>
<td>50.5 ± 18.4</td>
<td>-2.03</td>
<td>0.042</td>
</tr>
<tr>
<td>Social functioning</td>
<td>Resistance training</td>
<td>47.7 ± 16.6</td>
<td>70.5 ± 15.2</td>
<td>-3.59</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>49.1 ± 15.2</td>
<td>46.6 ± 13.7</td>
<td>-1.00</td>
<td>0.317</td>
</tr>
<tr>
<td>Role limitations due to emotional problems</td>
<td>Resistance training</td>
<td>7.8 ± 18.7</td>
<td>64.7 ± 29.9</td>
<td>-3.57</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>8.8 ± 19.7</td>
<td>8.8 ± 19.7</td>
<td>0.00</td>
<td>0.999</td>
</tr>
</tbody>
</table>

*M(SD)* mean ± standard deviation
Table 6
Results of the paired t-test to analyze within-group differences in QOL for both groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>Pretest M (SD)</th>
<th>Posttest M (SD)</th>
<th>T</th>
<th>Df</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General health</td>
<td>Resistance training</td>
<td>54.4 ± 25.0</td>
<td>79.41 ± 14.0</td>
<td>-6.56</td>
<td>16</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>45.6 ± 25.0</td>
<td>43.3 ± 24.6</td>
<td>2.43</td>
<td>14</td>
<td>0.029</td>
</tr>
<tr>
<td>Vitality (Energy/fatigue)</td>
<td>Resistance training</td>
<td>42.6 ± 16.8</td>
<td>71.1 ± 11.5</td>
<td>-9.73</td>
<td>16</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>52.00 ± 21.9</td>
<td>49.6 ± 21.7</td>
<td>1.52</td>
<td>14</td>
<td>0.150</td>
</tr>
<tr>
<td>Emotional well-being</td>
<td>Resistance training</td>
<td>49.6 ± 21.6</td>
<td>75.7 ± 14.5</td>
<td>-9.22</td>
<td>16</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>53.3 ± 21.0</td>
<td>51.2 ± 20.3</td>
<td>1.83</td>
<td>14</td>
<td>0.088</td>
</tr>
<tr>
<td>Total SF-36 score</td>
<td>Resistance training</td>
<td>49.0 ± 17.1</td>
<td>78.0 ± 11.7</td>
<td>-13.61</td>
<td>16</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>46.0 ± 19.4</td>
<td>42.9 ± 16.5</td>
<td>1.64</td>
<td>14</td>
<td>0.122</td>
</tr>
</tbody>
</table>

M(SD) mean ± standard deviation

In addition, Tables 7 and 8 report the results of the Mann-Whitney U test and those of the independent t-test to analyze differences between the two groups in the QOL. In fact, there were significant differences between the resistance training group and the control group in the posttest scores of QOL (P = 0.001). Moreover, differences in the posttest scores of all QOL indices were significant for both groups.
Table 7
Results of the Mann-Whitney U test to analyze differences in QOL for both groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Time</th>
<th>Average rank</th>
<th>U</th>
<th>Z</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resistance training</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical functioning</td>
<td>Pretest</td>
<td>19.3</td>
<td>13.3</td>
<td>79.5</td>
<td>-1.82</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>22.6</td>
<td>9.5</td>
<td>23.5</td>
<td>-3.99</td>
</tr>
<tr>
<td>Role limitations due to physical health</td>
<td>Pretest</td>
<td>16.9</td>
<td>16.0</td>
<td>120.5</td>
<td>-0.27</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>22.4</td>
<td>9.7</td>
<td>26.0</td>
<td>-4.04</td>
</tr>
<tr>
<td>Pain</td>
<td>Pretest</td>
<td>18.0</td>
<td>14.8</td>
<td>102.0</td>
<td>-0.97</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>22.2</td>
<td>10.0</td>
<td>30.0</td>
<td>-3.72</td>
</tr>
<tr>
<td>Social functioning</td>
<td>Pretest</td>
<td>16.1</td>
<td>16.8</td>
<td>122.0</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>22.2</td>
<td>9.9</td>
<td>29.5</td>
<td>-3.80</td>
</tr>
<tr>
<td>Role limitations due to emotional problems</td>
<td>Pretest</td>
<td>16.3</td>
<td>16.7</td>
<td>124.5</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>22.7</td>
<td>9.3</td>
<td>20.5</td>
<td>-4.24</td>
</tr>
</tbody>
</table>

Table 8
Results of the independent t-test to analyze within-group differences in QOL for both groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Time</th>
<th>Average</th>
<th>T</th>
<th>Df</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Resistance training</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General health</td>
<td>Pretest</td>
<td>54.4</td>
<td>45.6</td>
<td>0.98</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>79.4</td>
<td>43.3</td>
<td>5.00</td>
<td>21.6</td>
</tr>
<tr>
<td>Vitality (Energy/fatigue)</td>
<td>Pretest</td>
<td>42.6</td>
<td>52.0</td>
<td>-1.36</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>71.1</td>
<td>49.6</td>
<td>3.42</td>
<td>20.6</td>
</tr>
<tr>
<td>Emotional well-being</td>
<td>Pretest</td>
<td>49.6</td>
<td>53.3</td>
<td>-0.48</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>75.7</td>
<td>51.2</td>
<td>3.95</td>
<td>30</td>
</tr>
<tr>
<td>Total SF-36 Score</td>
<td>Pretest</td>
<td>49.1</td>
<td>46.0</td>
<td>0.47</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>78.0</td>
<td>42.9</td>
<td>6.82</td>
<td>24.9</td>
</tr>
</tbody>
</table>

Discussion

This study aimed to analyze the effects of eight-week resistance training on QOL and sleep quality among untrained men who had contracted COVID-19. According to the results, eight weeks of resistance
training significantly improved all indices and total sleep quality (P = 0.001) after the intervention. The COVID-19 pandemic has caused physical, psychological, and functional problems in society, especially affecting positive cases. It has also adversely impacted their QOL and sleep quality. Different studies (4, 5) have reported that the consequent problems emerge at the onset of symptoms (i.e., acute COVID-19) and persist for several months after the initial contraction (i.e., long COVID-19). These reports highlight the role of sports rehabilitation in improving the conditions of people with a history of COVID-19. Hence, this study aimed to determine the role of resistance training in the rehabilitation (i.e., QOL and sleep quality) of people who had contracted COVID-19.

Given the novelty of the research subject, the researcher claims that there are insufficient studies addressing the effect of resistance training on the QOL among patients with a history of COVID-19. Therefore, relevant studies were reviewed to justify the results. In fact, the results of this study regarding sleep quality are consistent with the findings reported by Silva-Batista et al. (17), who concluded that two weekly sessions of resistance training for 12 weeks had significant effects on the sleep quality improvement among 22 patients with Parkinson's disease. Andreu-Caravaca et al. (18) analyzed the effects of 10-week resistance training on patients with MS. In their study, 18 patients performed resistance training exercises three times weekly. The results indicated that resistance training exercises enhance patients' sleep quality. Moreover, Polito et al. (35) reported significant improvements in the sleep quality following six weeks of resistance training in sedentary people with sleep disorders.

The results of this study regarding the sleep quality were not consistent with the findings reported by Benloucif et al. (36), who analyzed the effects of two-week sports exercises on the sleep quality among patients with sleep disorders. According to their results, two weeks of sports exercises had no significant effects on sleep quality. In addition, various factors such as research methodology, age, gender, health status, BMI, types of sports exercises, and durations of sports exercises can affect the research results, leading to inconsistent results. The sports intervention duration was the most important reason for the inconsistency of these two studies. The participants in the present study performed resistance training exercises for eight weeks, whereas the participants in the study conducted by Benloucif et al. performed sports exercises for only two weeks. In fact, the effects of sports exercises on sleep quality among participants were not adjusted in that study.

According to the findings, eight weeks of resistance training led to significant improvements in all indices and total QOL (P = 0.001) after the intervention. The pretest scores of QOL indices were compared with the posttest scores in the control group. The comparisons indicated that physical functioning, role limitations due to physical health, pain, general health, vitality, social functioning, and emotional well-being were exacerbated after eight weeks in the control group; however, there were no changes in role limitations due to emotional problems. Moreover, changes were significant only in physical functioning, role limitations due to physical health, pain, and general health, whereas they were not significant in other indices. The control group's results highlighted the role of resistance training in preventing a steep decline in the QOL among people who had contracted COVID-19. Furthermore, the mean posttest scores of all
QOL indices for participants in the resistance training group were higher than the mean pretest scores of the same indices, indicating that resistance training positively affected the QOL.

The results of this study regarding the QOL were consistent with the findings reported by Dalbosco-Salas et al. (19), Betschart et al. (37), and Nambi et al. (20). However, our findings are incompatible with those of Sabapathy et al. (38). Sabapathy et al. investigated the effect of eight weeks of resistance training on the quality of life of individuals with MS, indicating that the protocol had an insignificant effect on the participants' quality of life. One of the primary reasons for this inconsistency is the difference in the number of training sessions and the type of participants in the research. Indeed, in our study, the participants did resistance training three times a week, while in the research by Sabapathy et al., resistance training was performed twice weekly.

Regarding the explanation of results, it is fair to state that improving mental and physical health can enhance sleep quality. Indeed, resistance training exhausts trainees, thereby helping them sleep better. Anxiety alleviation, depression mitigation, and happiness escalation can also improve sleep quality. In this regard, reports have indicated that resistance training can improve the sleep quality due to anti-depression and anti-anxiety effects (25). Resistance training can also boost mental and physical health by causing biological and biochemical changes, which will improve sleep quality (39). According to Simpson et al., inflammatory factors have adverse effects on sleep quality; therefore, doing resistance training exercises with anti-inflammatory effects can improve sleep quality (40). Similarly, Souza et al. (41) have reported that 12 weeks of resistance training mitigate inflammatory factors and enhance the sleep quality. At the same time, research evidence (42) has indicated that melatonin can have sedative effects on the sleep quality by changing the core body temperature. Moreover, resistance training deeply affects melatonin (43), which can be a possible factor contributing to resistance training's impact on participants' sleep quality.

According to the findings of this study and those of other studies regarding the QOL (44, 45), resistance training can enhance the QOL. Hence, given the outbreak of the COVID-19 pandemic and most people's sedentary lifestyles reducing their physical functions, resistance training can improve their QOL by boosting their physical functions. Many studies (24, 46) have indicated that resistance training enhances strength and muscular endurance, thereby improving physical function. The participants in this study reported higher levels of QOL after the intervention, which can primarily be attributed to improved physical functioning resulting from the effects of resistance training on strength and muscular endurance. In fact, the results of the present study indicate that resistance training improves the physical functions of participants significantly. At the same time, human health is correlated with the quantity and sleep quality. In other words, insomnia can affect the QOL and increase the risks of depression and anxiety, in addition to reducing the ability to cope with daytime tensions (47). Likewise, Reimer et al. (48) have indicated that treating sleep disturbances such as waking up frequently could enhance physical function and improve the QOL. Therefore, participants were expected to have a higher QOL after their sleep quality improved.
An important limitation of this study was the failure to control the vaccination status of participants. Given the role of vaccination in improving complications caused by COVID-19 (49), future studies are expected to control the vaccination status of participants in order to acquire more accurate results.

**Conclusions**

Overall, the results of this study indicate that resistance training can be employed as a therapeutic method to enhance QOL and sleep quality, as well as prevent the exacerbation of associated complications, in people who have contracted COVID-19.

**Declarations**

**Ethics approval and consent to participate** All methods performed in this study were in compliance with the Declaration of Helsinki. Ethical approval was obtained from the Biomedical Research Ethics Committee of the University of Tehran, and an ethics code (IR.UT.SPORT.REC.1401.005) was conferred. Written informed consent was obtained from all participants before the initiation of the experimental procedures to ensure their willingness to participate in the study.

**Consent for publication** All participants provided written consent for publication of their data while ensuring confidentiality. No objections regarding data use have been raised.

**Availability of data and materials** The datasets generated and/or analyzed during the current study can be made available on request by contacting the corresponding author.

**Competing interests** The authors have no competing interests to declare.

**Funding** This study received no external funding.

**Author Contributions** All authors contributed to the study conception and design. Data collection and analysis were performed by MBK (Morteza Bagheri Kalayeh) and MBK (Mahdieh Bagheri Kalayeh). The first draft of the manuscript was written by MBK (Morteza Bagheri Kalayeh). AAG and MRK commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**References**


Figures
Flowchart of the study