EFFECTS OF DOUBLE POLING ERGOMETER TRAINING ON AEROBIC AND MECHANICAL POWER IN PERSONS WITH SPINAL CORD INJURY

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SUMMARY

The study investigated the effects of double-poling ergometer training, performed by persons with spinal cord injury (SCI), on aerobic and mechanical power. Twelve post-rehabilitated persons with an SCI (T5 to L1) trained on a double-poling ergometer for 10 weeks. Before and after the training period, aerobic and mechanical power was measured during maximal double-poling exercise on the ergometer. There were significant improvements in oxygen consumption (22.1 %), ventilation (18.8 %), and blood lactate (25.7 %). Mean power per stroke and peak pole force increased after training with 12.5 % and 17.6 %, respectively. This new training device appears to be an effective training tool for persons with SCI.

INTRODUCTION

Post rehabilitation, the need for physical training still remains, to maintain the acquired abilities and avoid risks involved with a sedentary lifestyle [1,2]. Apart from improving physical capacities, participation in physical activities has numerous benefits, it may help to reduce depression, improve social interaction and prolong life expectancy [3]. Sit-skate is a leisure activity that is accessible for individuals with SCI and appears to have the potential to develop various desirable physical capacities, such as endurance, balance and strength. The double poling movement has in clinical practice been shown to be easy to learn, and the smooth character of the movement does not seem to lead to any shoulder problems or other overload symptoms. However, it is not possible to perform in many countries.

Training indoors in a double-poling ergometer is an alternative to outdoor skating, with the obvious advantage of being weather independent. A further advantage of the ergometers is the possibility of controlling the intensity of the activity. Double-poling ergometers are commercially available for persons that are able to stand, and are widely used among competitive cross-country skiers, but have to our knowledge not previously been modified or tested for persons with SCI.

METHODS

Subjects

Twelve persons with an SCI (7 M and 5 F; 48.9 ± 10 years, 1.75 ± 0.08 m, 67.7 ± 10.8 kg) with injury ranging from T5 to L1, participated in the study. A description of the participating persons based on the ASIA (American Spinal Injury Association) impairment scale [4], age, years post injury, weight and height, is presented in Table 1. The study was approved by the Stockholm Regional Ethics Board. All subjects were provided with oral and written information, and gave their informed consent to participate prior to the study.

Table 1. Description of the subjects with spinal cord injury

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Years post-injury</th>
<th>Gender</th>
<th>Neurologic lesion level</th>
<th>AIS*</th>
<th>Height</th>
<th>Weight Pre/Post</th>
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<tbody>
<tr>
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<td>49</td>
<td>29</td>
<td>M</td>
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<td>M</td>
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<tr>
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<td>25</td>
<td>M</td>
<td>T6</td>
<td>B</td>
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<tr>
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<td>45</td>
<td>35</td>
<td>F</td>
<td>T6</td>
<td>C</td>
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<td>58.8</td>
</tr>
<tr>
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<td>55</td>
<td>15</td>
<td>F</td>
<td>T5-8</td>
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<td>33</td>
<td>F</td>
<td>T9</td>
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<td>M</td>
<td>L1</td>
<td>A</td>
<td>1.86</td>
<td>67.5</td>
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</table>

*In the ASIA (American Spinal Injury Association) Impairment Scale, “A” represents complete impairment, i.e. no sensory or motor function in the S2-S4 segment, “B”, incomplete impairment with sensory but no motor function below the neurological level, and “C”, incomplete impairment, i.e. motor function with a muscle grade less than 3 below the neurological level [4].

Ergometer

A custom-built seated double poling ergometer modified for persons with motor impairments in the lower extremities was used in the study (Figure 1). To secure the sitting position a custom-designed seat with adjustable backrest and foot brace was mounted on the ergometer. The ergometer is equipped with a display, which provides information on the subject’s performance, such as distance, speed, intensity and stroke rate. The resistance on the ergometer could be adjusted by regulating the air-intake on the flywheel from 1 (lightest) to 10 (heaviest). The resistance was set at 4 throughout this study.
Training
Subjects trained on the double-poling ergometer three times per week during a 10-week period; the total number of session was 30 for each subject. All sessions were carried out in small groups and were supervised by an instructor. Each session lasted approximately 55 min and included a warm-up, interval training (15 s – 3 min work and 15 s – 2 min rest) and a cool-down. During the first two weeks, subjects were taught double poling technique and introduced to interval training. After the familiarization the training intensity were progressively increased during the training period and a new training program was introduced every second week. The intensity of the intervals was determined to lead up to 70 – 100 % of peak heart rate obtained during the initial maximal oxygen uptake test. If a higher peak heart rate was detected during training, the level of intensity was adjusted.

Test equipment and procedure
Before and after the training period, aerobic and mechanical power was measured during maximal double-poling exercise on the ergometer. Oxygen consumption (VO2peak, l/min, ml/kg/min) and ventilation (l/min) were obtained by using the Douglas Bag system. Heart rate (bpm) was continuously registered by a Polar watch and blood lactate (mmol/l) was taken 1 min after the test. During the test, 3D movement data were recorded from the poles using an optoelectronic system (Qualisys, Göteborg, Sweden). The camera set-up included eight cameras that were placed in a circle approximately 3 m around the ergometer and four reflective markers were attached on each pole, respectively.

Prior to the test, subjects performed a five minute warm-up on the ergometer at 5 W. The subjects were then introduced to the test procedure and the use of the Borg-scale (RPE 6-20). During the test subjects were instructed and strongly encouraged to achieve their maximum effort during the last minute of the 5-6 min test. The intensity was increased every minute until exhaustion, starting at 10 W and then, from 13 (somewhat hard), 15 (hard), 17 (very hard) to 20 (maximal exertion) corresponding to the Borg-scale.

RESULTS AND DISCUSSION
Peak oxygen uptake increased significantly (p<0.001) from 1.23 ± 0.37 l·min⁻¹ (mean ± SD) before to 1.48 ± 0.41 l·min⁻¹ after training. The corresponding values for ml/kg·min⁻¹ was significantly increased (p<0.001) from 17.9 ± 4.42 before to 21.87 ± 5.12 after training. There was a significant improvement (p=0.002) in ventilation from 64.4 ± 20.8 before to 75.5 ± 24.6 l/min after training. Blood lactate increased significantly (p=0.03) from 6.59 ± 1.84 before to 7.95 ± 2.36 mmol/l after training. The highest heart rates noted during the maximal test were similar before and after training, mean values being 164 (range 133-183) and 165 beats/min (136-191), respectively, no significant differences were observed.

CONCLUSIONS
The main findings of this study were that persons with long-standing SCI were able to improve aerobic and mechanical power after a 10-week period of double poling ergometer training. In addition, the training on the ergometer, albeit intense, did not cause any shoulder pain or other problems. The training tool provides a large range of controllable intensities enabling both endurance and strength/sprint type of training.

ACKNOWLEDGEMENTS
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REFERENCES