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ORIGINAL RESEARCH

Feasibility of Handcycle Training During Inpatient Rehabilitation in Persons With Spinal Cord Injury

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Abstract

Objective: To assess the feasibility of a handcycle training program during inpatient rehabilitation and the changes in physical capacity in persons with subacute spinal cord injury (SCI).

Design: Before-after trial.

Setting: Rehabilitation centers.

Participants: Persons with subacute SCI in regular rehabilitation (N=45).

Interventions: A structured handcycle interval training program during the last 8 weeks of inpatient rehabilitation. Training was scheduled 3 times per week (24 sessions total), with an intended frequency of ≥2 times per week. Intended intensity was a Borg score of 4 to 7 on a 10-point scale.

Main Outcome Measures: Feasibility was assessed, and participant satisfaction was evaluated (n=30). A maximal handcycling test was performed 8 weeks prior to discharge and at discharge to determine peak power output and peak oxygen uptake (Vo_2peak) (n=23).

Results: Of the participants, 91% completed the handcycle training, and no adverse events were reported. Mean training frequency was 1.8±0.5 times per week, and mean Borg score was 6.2±1.4. Persons with complete lesions demonstrated lower training feasibility. Most participants were satisfied with the handcycle training. Peak power output and Vo_2peak improved significantly after the training period ($P<.01$) by 36.4% and 9.6%, respectively.

Conclusions: Overall, handcycle training during inpatient rehabilitation in persons with SCI was feasible except for the training frequency. Persons with complete lesions likely need extra attention to benefit optimally from handcycling training. Because the improvements in physical capacity were larger than those known to occur in persons with paraplegia receiving regular rehabilitation, the results suggest that the addition of handcycle training may result in larger increases in physical capacity compared with regular rehabilitation only.

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Handcycling has been suggested as an appropriate training method for persons with spinal cord injury (SCI) because handcycling is less strenuous and the risk of upper-extremity overuse injury is smaller compared with handrim wheelchair propulsion.[1] Integrating handcycle training into the rehabilitation program of this vulnerable group may be challenging.[2,3] Feasibility knowledge is important to facilitate successful implementation. The purpose of this study was to assess the feasibility of a handcycle training program during inpatient rehabilitation and the changes in physical capacity in persons with subacute SCI.

Methods

Persons were recruited from 4 Dutch rehabilitation centers. Inclusion criteria were as follows: initial inpatient rehabilitation, dependence on a manual wheelchair, and age 18 to 65 years. The Medical Ethics Committee of Erasmus Medical Center Rotterdam,

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Table 1 Training frequency and training intensity

Total Group and Subgroups	Training Frequency (sessions/wk)	Training Intensity (Borg)
Total group (n=30)	1.9 (1.4–2.2)	6.5 (5.1–7.4)
Subgroup 1		
Paraplegia (n=20)	1.9 (1.3–2.2)	6.0 (4.4–6.9)
Tetraplegia (n=10)	1.9 (1.7–2.2)	7.0 (6.4–7.9)
Mann-Whitney *U* test	*U*=88.0, *P*=.62	*U*=53.0, *P*=.04
Effect size, *r**	0.1	0.4
Subgroup 2		
Incomplete lesion (n=12)	2.1 (1.9–6.8)	7.4 (6.8–8.1)
Complete lesion (n=18)	1.7 (1.1–2.0)	5.7 (4.3–6.4)
Mann-Whitney *U* test	*U*=52.0, *P*=.02	*U*=27.0, *P*<.01†
Effect size, *r**	0.4	0.6

NOTE. Values are median (IQR) or as otherwise indicated.
* $r=Z/\sqrt{n}$.
† Significant difference, *P*<.013.

The Netherlands, approved the protocol of this study, and all participants provided written informed consent.

All participants participated in a structured handcycle training program during the last 8 weeks of inpatient rehabilitation. The training, performed on an add-on handcycle, was supervised by a sports therapist and consisted of an interval training protocol tailored to the individual.[4] During the first week of training, the sessions consisted of 6 repetitions of 3 minutes of handcycling, each followed by a 2-minute interval of active rest during which participants cycled at low resistance. During the 8 weeks of handcycle training, the number of repetitions and handcycle time increased, whereas the rest time decreased. The last week of training consisted of 7 repetitions of 4 minutes of handcycling with rest intervals of 1.5 minutes. Training was performed indoors by placing the handcycle in an ergotrainer or outside. Each training session lasted 45 to 60 minutes, including short warming-up and cooling-down periods. Training was scheduled for 3 times a week (24 sessions total), with an intended frequency of ≥2 times per week. Training intensity was controlled by measuring central cardiovascular perceived exertion from 0 to 10 on a Borg scale after each training session.[5,6] Intended intensity was a Borg score between 4 and 7.

For feasibility, training details were registered by sports therapists in a handcycle training journal. Furthermore, at the end of the training period, a self-set evaluation form was completed by participants. This included questions on general satisfaction and satisfaction with training frequency, training intensity, starting time in rehabilitation, and total training program duration, with answering possibilities satisfied or not satisfied for which reason.

Before and after handcycle training, participants performed a maximal handcycle test on an add-on handcycle placed in a Tacx Flow Ergotrainer.[a] The resistance was increased every minute by 2 to 10 W, as estimated based on lesion characteristics, and adjusted where necessary such that the duration of the test would be 8 to 12 minutes. Throughout the test, participants cycled at a cadence of 60 revolutions per minute. The test ended when the participant stopped voluntarily because of exhaustion or when the participant was unable to maintain the target cadence. Peak power output measured with the Tacx Flow Ergotrainer[7] (W and W/kg) was defined as the highest power output sustained for at least 30 seconds. Peak oxygen uptake[b] (Vo_2peak) (L/min and mL/kg/min) was defined as the highest mean oxygen uptake measured in periods of 30 seconds.

Tetraplegia was defined as a lesion at or above the T1 segment, and paraplegia was defined as a lesion below T1. Motor completeness included American Spinal Injury Association Impairment Scale grades A and B, whereas motor incompleteness included grades C and D.

List of abbreviations:

IQR **interquartile range**
SCI **spinal cord injury**
Vo_2peak **peak oxygen uptake**

Data analysis

Nonparametric tests were used because Shapiro-Wilk tests showed that not all variables were normally distributed. Mann-Whitney *U* tests were used to test for differences in training frequency and training intensity between subgroups based on lesion characteristics. Wilcoxon signed-rank tests were used to test for differences in physical capacity before and after training. Statistical analysis was performed using SPSS version 21,[c] and significance level with Bonferroni correction was *P*<.013 (0.05/4).

Results

Forty-five persons were included (median age, 44y; interquartile range [IQR], 30–56y); of the participants, 87% were men, 67% had paraplegia, and 64% had motor complete lesions. The median time since injury was 128 (IQR, 90–173) days, median time in rehabilitation was 84 (IQR, 59–125) days, and the cause of the lesion was traumatic in 68% of participants.

Forty-one participants (91%) completed the training. Training was not completed by 4 participants because of severe pressure ulcers and therefore bed rest (n=2), forced discharge before start of training (n=1), and dislike of training (n=1). Three participants who did not complete the training had paraplegia, and all had complete lesions. No adverse events related to handcycle training were reported.

Of the remaining 41 participants, training journals were available for 30 participants. Training journals were missing because of change in trainers (n=5), inaccuracies of the trainers