GREATER ENJOYMENT IN TWO MODES OF HIGH INTENSITY INTERVAL TRAINING (HIIT) COMPARED TO CONTINUOUS EXERCISE TRAINING (CEX) IN PERSONS WITH SPINAL CORD INJURY (SCI)

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Introduction

Physical and psychological health are dramatically impacted by onset of spinal cord injury (SCI). Reductions in peak oxygen uptake (VO_2peak) (9), muscle mass (6), and the onset of chronic pain (16) and depression (12) contribute to sedentarism and reduced physical function (10). The recommended 150 min/wk of moderate exercise or 75 min of vigorous exercise for adults (7) is often unattainable in SCI due to barriers of exercise including lack of access to specialized facilities, lack of motivation, and the failure of their physician(s) to emphasize the benefits of exercise (19). Consequently, persons with SCI demonstrate markedly higher rates of obesity, diabetes, and heart disease than able-bodied populations (2). Overall, there is a need to identify forms of exercise that are time and cost-efficient, effective, and appealing within the SCI population.

The efficacy and practicality of high-intensity interval training (HIIT), repeated, brief bursts of intense exercise separated by recovery, have been repeatedly demonstrated in able-bodied populations. Data show significant improvements in VO_2peak, glycemic control, and fat use following only 6 d of HIIT (1, 14). These improvements are similar (3) and in some cases superior (17) in magnitude compared to those acquired from continuous moderate exercise (CEX), which meets the public health recommendations for physical activity. Despite the positive effects of HIIT shown in persons with obesity (20), heart disease (21), and stroke (5), it has been criticized (8) as being impractical for non-athletes due to the breathlessness, fatigue, and muscle pain that it induces. Whether HIIT is feasible in persons with SCI is unknown.

In this study, the efficacy and practicality of HIIT for persons with SCI were considered by examining metabolic and perceptual responses to exercise. It was hypothesized that the completion of low-volume HIIT would be well-tolerated with no side effects, and perceptual ratings of exercise enjoyment would be greater in response to HIIT versus CEX.

Methods

Participants

Nine men and 1 woman (age: 33.3 $\pm$ 10.4 yr; BMI: 22.6 $\pm$ 3.1 kg/m^2; 2 tetraplegic and 8 paraplegic) completed 4 exercise sessions. Participants were between 18-60 yr of age and had SCI for 6.8 ± 6.2 yr. Exclusion criteria included the presence of any pulmonary, cardiovascular, or metabolic diseases as well as use of medications or supplements which alter our outcome measures. This information was confirmed by a standardized health questionnaire.

Baseline Assessment

Initially, participants completed graded arm ergometry (Angio, Lode, Groningen, Norway) to assess VO_2peak and maximal workload (Wmax). During exercise, heart rate (HR) was assessed via telemetry (Polar, Woodbury, NY) and gas exchange data were obtained every 15 s using a metabolic cart (ParvoMedics True One, Sandy, Utah). Maximal workload (in Watts) from this bout was used to determine the exercise intensities of subsequent trials. Blood lactate concentration (BLa) was measured prior to exercise and 3 min post-exercise (Nova Biomedical, Lactate Plus, Waltham, Massachusetts).

Completion of HIIT, SIT, and CEX

Three subsequent exercise sessions consisted of CEX, HIIT, and sprint interval training (SIT) in randomized order. Each session was separated by at least 48 h and performed at the same time of day within subjects. High intensity interval training consisted of eight 60 s bouts at 70 %Wmax separated by 90 s of recovery at 10 %Wmax. SIT was composed of eight 30 s bouts at 105% Wmax separated by 120 s of recovery at 10 %Wmax. During CEX, participants exercised at 45 %Wmax for 25 min. HR and BLa were recorded at the following session increments: 0%, 25%, 50%, 75%, 100%, and 3-min post exercise.

Rating of Perceived Exertion and Exercise Enjoyment

Rating of Perceived Exertion (4; RPE) was assessed at 0%, 25%, 50%, 75%, and 100% of session completion as well as 5 min post-exercise. Participants were informed that RPE was related to their sensations of breathing, heart rate, and level of fatigue. Ten minutes post-exercise, the Physical Activity Enjoyment Scale (PACES) was completed (13). This scale was used to assess levels of enjoyment for each bout using participant responses to 20 questions scored on a 1 – 7 Likert scale. Afterwards, participants were asked which modality of exercise they ultimately preferred.

Statistical analyses

Data are reported as mean ± SD and were analyzed using SPSS (Chicago, IL). Repeated measures analysis of variance was used to assess differences in HR, VO_2, BLa, and RPE across time and between exercise modes. One-way ANOVA with repeated measures was used to examine differences in enjoyment. Significance was set as $p < 0.05$.

Results

Mean VO_2peak was equal to 17.4 ± 4.7 mL/kg/min, respectively. One participant withdrew from the study after the VO_2peak test due to an unrelated injury, leaving a full set of data for nine participants.

Differences in VO_2, HR, and BLa in response to HIIT, SIT, and CEX

These data are shown in Figure 1a-c. Oxygen uptake (VO_2) was significantly different across time ($p = 0.000$), and a significant main effect ($p = 0.02$) and boutXtime interaction ($p = 0.003$) were observed. Post hoc analyses showed higher VO_2 in HIT versus CEX at 75 % and at end-exercise, when VO_2 was higher in response to HIT and SIT versus CEX. Significant differences in HR were seen across time ($p = 0.000$) as well as a significant main effect ($p = 0.007$) and boutXtime interaction ($p = 0.000$). At all exercise time points, HR was higher in

SIT/HIIT versus CEX. During HIIT and SIT, VO_2 and HR surpassed 90% of peak values. Additionally, BLa was significantly different across time (p=0.000) and bouts (p = 0.000), and data showed a significant boutXtime interaction (p = 0.000). Post hoc analyses revealed that BLa was different at 25 % (SIT vs. CEX), at 75 % (HIT and SIT vs. CEX), and at 50 and 100 % (HIT vs. SIT vs. CEX) of session duration.

Differences in Physical Activity Enjoyment and RPE in response to HIIT, SIT, and CEX

PACES was significantly different across bouts (p = 0.008), with post hoc analyses demonstrating that SIT (103.7 ± 12.5) and HIIT (107.4 ± 13.4) produced higher enjoyment versus CEX (81.6 ± 25.4). Rating of Perceived Exertion differed across time (p=0.000) and bout (p=0.02). A significant boutXtime interaction was observed (p=0.000). Post hoc analyses showed that RPE in HIIT and SIT was higher than CEX at 50, 75, and 100 % of exercise (Figure 1d).

Discussion

Inconsistencies in the severity of SCI make specialized rehabilitation such as locomotor training or activity-based therapy very costly, time-consuming, and impractical (18). The identification of practical modalities of exercise for persons with SCI is important to create an effective wellness plan for this population. According to Burgomaster et al. (3), interval training has been shown to elicit comparable physiological adaptations to endurance training despite a much lower training volume and time commitment. Although a lower time commitment of exercise may increase exercise adherence, whether HIIT is feasible in the SCI population remains unclear. This study examined differences in enjoyment and various physiological and psychological variables between CEX and two approaches of HIIT. Our data demonstrated greater enjoyment in HIIT and SIT compared to CEX despite greater metabolic stress (HR, VO_2, and BLa).

Three potential factors may explain significantly higher enjoyment found in HIIT/SIT compared to CEX. The unique structure of HIIT, consisting of brief, intense bursts of exercise separated by recovery is one possible explanation for these findings. The dynamic structure of HIIT provides participants with multiple recovery periods that provide a "break" from less positive affective responses (11) which are seen with continuous exercise. Secondly, participants in the current study reported CEX as monotonous and generally did not enjoy maintaining a moderate effort for $\geq$25 min. In addition, a certain level of accomplishment is experienced during HIIT that is not apparent in CEX (11). Overall, this may give the exerciser a greater amount of self-confidence explaining why significantly more participants preferred HIIT to CEX. Lastly, the lower total exercise volume of HIIT may reduce perception of difficulty and increase feelings of pleasure. HIIT does not seem to lead to severely negative perceptions in individuals unaccustomed to intense exercise (15, 22), and actually appears to augment perceptual responses compared to prolonged bouts of exercise where continuous effort must be sustained over an extended period (11). This may make incorporation of chronic HIIT regimes more appealing in persons on the low end of the fitness spectrum such as persons with SCI.

Conclusion

Low-volume HIIT can be performed by men and women with SCI without complications. Although HIIT induces higher HR, VO_2, and BLa compared to CEX, this may elicit greater enjoyment. Potential exists for chronic HIIT to improve cardiorespiratory fitness and overall health status in individuals with SCI.

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Figure Legends

Figure 1a: Change in VO_2 in response to high intensity interval training, sprint interval training, and continuous exercise. * = $p < 0.05$ between HIIT and CEX; # = $p < 0.05$ between HIIT/SIT and CEX.
Figure 1b: Change in heart rate in response to high intensity interval training, spring interval training, and continuous exercise. * = $p < 0.05$ between HIIT/SIT and CEX.
Figure 1c: Change in blood lactate concentration (mM) in response to high intensity interval training, sprint interval training, and continuous exercise. + = significant difference ($p < 0.05$) between SIT and CEX; a = ; $p < 0.05$ between all bouts; # = $p < 0.05$ between HIIT/SIT and CEX
Figure 1d: Change in Rating of Perceived Exertion in response to high intensity interval training, spring interval training, and continuous exercise. # = $p < 0.05$ between HIIT/SIT and CEX.