The Effects of High-Intensity Training on the Cybex Arc Trainer on Muscular Endurance and Work Capacity

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Introduction

Historically, research studies have examined the effects of strength, or resistance training on physiological outcomes. Both Macdonald (1983) and Reid et al (1987), for example, documented changes in body composition and cardiorespiratory function, after a prescribed course of strength training.

Rarely, on the other hand, have researchers determined whether a cardiovascular device can have a positive effect on muscular endurance or work capacity.

Previously, in our lab, we determined that the Cybex Arc Trainer allowed subjects to work at high intensities, as a result of its biomechanical design. We questioned, therefore, whether training on the Arc at sufficiently high workloads would improve overall work capacity and increase muscular endurance in a strength-based exercise.

Subjects and Methods

Ten healthy males (mean age, 39.7 ± 5.9 years) from a return to exercise program were randomly placed into the Arc training group. Ten age- and fitness-matched males (mean age, 37.8 ± 6.2 years) were then assigned to a control group. None of the subjects had a history of back, knee, hip or ankle injury.

Testing

Muscular endurance was determined by a unilateral leg press to failure on a Cybex Eagle Leg Press. The machine was adjusted so that all subjects moved through a consistent range of hip and knee motion. Subjects were given three warm-up sets during which they practiced moving to the target knee angle of 90 degrees. During the first set, they performed ten repetitions at 50% of their body weight with both legs. The second warm-up set consisted of five repetitions on each leg, individually, at 50% of their body weight. During the final warm-up set, five repetitions were completed on each leg at 75% of their body weight. The pre-test was conducted once the subjects indicated that they were able to perform maximum repetitions, to failure, at 75% of their body weight.

Once positioned in the machine, subjects pressed into full knee extension with both legs, removed one leg, and held it up without touching the ground or the device for the duration of the test. At this point, the subject flexed the working knee to ninety degrees of flexion in one second, and without pausing, pressed back up without locking out the knee. This extension phase was also completed in one second. This two-second lowering and raising motion counted as one complete repetition. The subject stayed with this cadence of one second down and one second up for as many repetitions as they could perform. Once cadence was broken or the subject paused, the test was stopped and total repetitions were recorded. The subject was given two minutes recovery and then repeated the test on the other leg. This process was repeated two times on each leg with two minutes recovery between each set.

To measure steady state work capacity, subjects performed four, five-minute interval trials on the Cybex Arc Trainer. Each interval trial consisted of a four-minute work bout followed by a one-minute rest period. The machine's incline was set to six and the subjects' body weights were entered before the test began.

Subjects selected a resistance that they could maintain for four minutes and were instructed to sustain a cadence of 120 strides per minute (SPM) throughout the test. If a subject could not keep the 120 SPM pace, the resistance was lowered to a level that would ensure the proper cadence. The steady state resistance during the last minute of each interval was recorded as the resistance for that interval. Steady state work capacity was measured in watts, and was calculated by a computer algorithm using body weight, incline of the machine, strides per minute, and resistance.

Subjects were post tested one week after the end of the study under the same procedures used during the pre test.

Arc Trainer Protocol

After practicing on the Arc trainer, the Arc group exercised three days per week for three weeks. The initial session was an interval protocol designed to establish exercise workloads. The protocol consisted of four minutes of work at an arbitrary workload, and a pace of 120 strides per minute (SPM), followed by a one minute rest interval. This was repeated four times, for a total of nineteen minutes.

If the subject could keep pace at the established workload for the entire four-minute interval, resistance was increased. If at any time SPM dropped below 120, resistance was lowered to a level at which the subject could maintain the prescribed pace.

The second session involved twenty-second sprint intervals, using the maximum resistance from the four-minute protocol as a starting workload. Subjects were given three minutes to adjust to the settings and attempted several five- to ten-second practice "sprints," gradually increasing their cadence to 170 SPM.

After a two-minute rest period, the subject performed a ten-second build-up to 170 SPM, and then attempted to hold that pace for another twenty seconds. If cadence was sustained for the required twenty seconds, the workload was increased for the next interval. If at any point, the subject could not maintain the pace over the twenty seconds, the load was decreased. Each work interval was followed by ninety seconds of active recovery at a pace of less than 50 SPM.

The two workouts were alternated, with 48 hours of rest between them, for the three week period. The post test was administered within one week after the final training session.

Control group subjects did not exercise during the three-week training period.

Results

The results of the leg press and power tests for the Arc and Control groups are presented in the table below.

Results						
Group	**Leg Press (repetitions)**			**Work Capacity (watts)**		
	Pre	**Post**	**sig.**	**Pre**	**Post**	**sig**
Arc	17.1 ± 6.1	23.0 ± 7.3	P <.05	180.4 ± 30.4	230.1 ± 25.3	P < .05
Control	14.8 ± 4.7	14.3 ± 4.4	N.S.	179.7 ± 24.2	185.4 ± 23.3	N.S.
	N.S.	P < .05		N.S.	P < .05	

As indicated in the table, the pre-test leg press scores for the Arc and Control groups were statistically equivalent, as determined by a two-sample T-test. This is depicted graphically in figure 1.

After training, however, the Arc group's mean repetitions to failure increased by an average of nearly six repetitions, while the Control group's scores did not change. The Arc group's post-test scores, seen in figure 2, were significantly greater (p < .05) than the group's pre-test scores, and also greater than

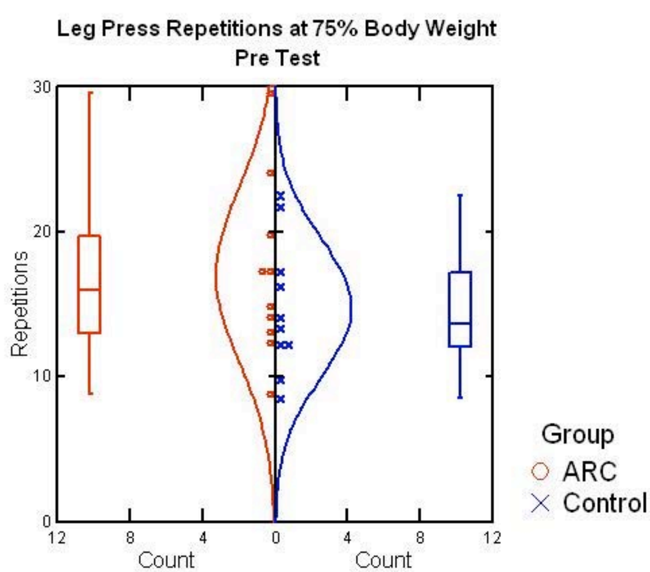

Figure 1. Two Sample T-Test of Leg Press

the Control group's post-test scores ($p < .05$), indicating an improvement in muscular endurance as a consequence of the Arc training protocol.

The pre-test work capacity scores, seen in figures 3 and 4 below, for the Control group and the Arc group were not significantly different. At the post-test, the Arc group's work capacity increased by nearly fifty watts, while the Control group's did not change. These differences were significant at the .05 confidence interval, indicating that the Arc Trainer protocol was effective in improving work capacity in normal healthy subjects.

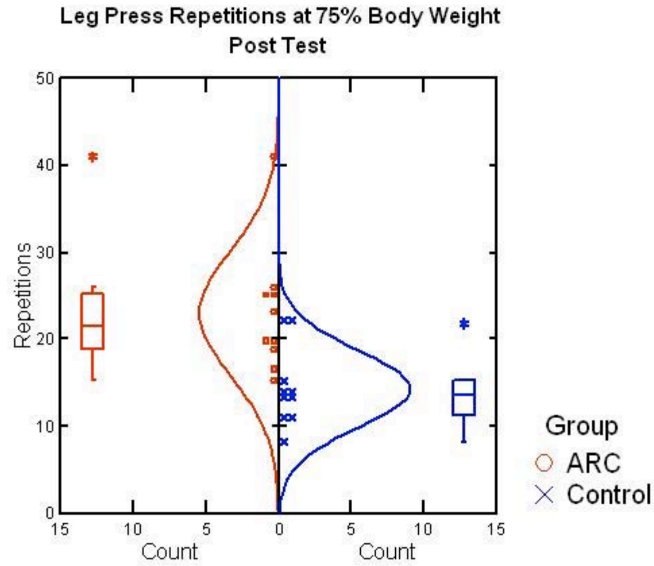

Figure 2. Two Sample T-Test of Leg Press

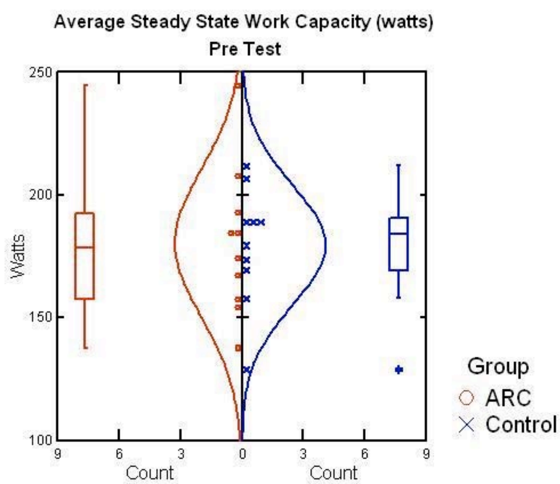

Figure 3. Two Sample T-Test of Work Capacity

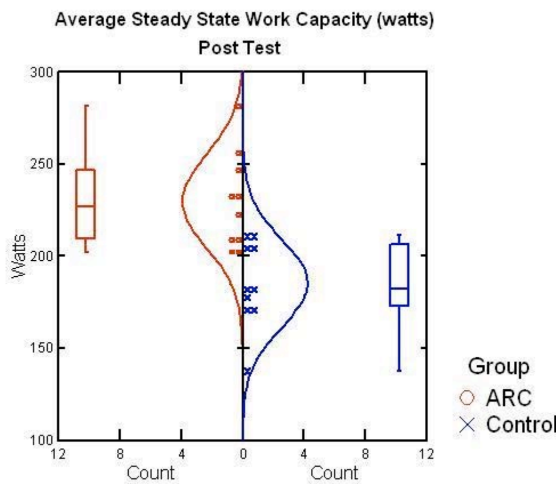

Figure 4. Two Sample T-Test of Work Capacity

Discussion

While previous research has traditionally examined the effects of strength devices on cardiovascular outcomes, this study posed the opposite question; whether a device which has been designed for cardiovascular exercise can have an effect on leg muscular endurance and steady state work capacity.

The results of this study indicate that the Cybex Arc Trainer can improve both muscular endurance and work capacity in healthy adult men. We attribute this to the fact that users of the device are able to train at intensities sufficiently high enough to induce the recorded effect. This is seemingly not always possible on non-impact cardiovascular machines. Turner et al (2008), for example, demonstrated that subjects experienced significantly higher perceived exertion and joint discomfort on an elliptical trainer, as compared to the Cybex Arc Trainer, at comparable workloads.

Subjects' ability to perform consistently high workloads on the Arc may be a result of the biomechanics of the machine, as described by Graves and Juris (2005). Further research with this device is warranted.

References

Graves, B.S. and Juris, P.M. (2005) A comparative kinematic and biomechanical analysis of two gait simulators. http://media.cybexintl.com/cybexinstitute/research/ArcTrainervsEllipticalStudy.pdf

Macdonald, R.P. (1983). Physiological changes seen after six weeks sequence training. British Journal of Sports Medicine. 17: 76-83.

Reid, C.M., Yeater, R.A., and Ullrich, I.H. (1987). Weight training and strength, cardiorespiratory functioning and body composition of men. British Journal of Sports Medicine. 21: 40-44.

Turner, M., Williams, A., Williford, A., Cordova, M. (2008). A Comparison of the physiological response and pain perception between two mechanically differentiated cross trainers. http://media.cybexintl.com/cybexinstitute/research/ARC%20Metabolic%20Costs.pdf