The Use of a Cardio Work Index to Determine the Effectiveness of High Intensity Interval Exercise on Three Lower Body Machines

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Introduction

High intensity interval training is frequently cited as being more beneficial than steady rate exercise for improvements in VO2max (Helgerud, et al) and even changes in body composition (Irving, et al). However, the ability of this form of exercise to deliver health benefits is, to a large extent, determined by how well one can tolerate the exercise in the first place.

If one cannot achieve an appropriately high exercise heart rate, or the duration of exercise is limited, then one might question whether the exercise will deliver the desired result. Kilpatrick and colleagues, for example, suggest that perceptions of effort may have a direct effect on the duration of aerobic exercise. This may further be compounded by the exercise device that is being utilized, and whether perceived exertion is measured in general terms or with a focus on a specific area.

The purpose of this study, therefore, was to establish an index of cardiovascular work based on the interaction of heart rate, perceived exertion, and duration of exercise. Additionally, perceived exertion was distinguished between overall exertion, and that of only the lower body. Lastly, this index was applied to three lower body exercise devices in order to measure their overall efficacy in producing a cardiovascular training response during high intensity interval exercise.

Subjects and Methods

Ten healthy males from a corporate wellness program volunteered to complete this two-week study. Their mean age was 39.7 ± 7.5 years. The participants were familiar with the equipment used in this study and had no prior injuries or health risks that would have precluded them from working towards elevated heart rates or levels of perceived exertion.

The subjects were given one week of practice on each of the testing devices, including a spinning bike, treadmill, and the Cybex Arc Trainer. During each practice session, they performed twenty minute workouts at a comfortable level, making adjustments to incline, resistance, and cadence.

Following practice, subjects were randomly assigned an order in which they would complete the test protocol on each of the three devices. Testing was conducted on one device per session, with forty eight hours rest between test sessions. The order of testing was counterbalanced across subjects so as to avoid any effects due to sequence.

The testing protocol consisted of a graduated, three-minute warm-up, which elevated the subject's level of perceived exertion to a seven on the RPE scale, as identified in the accompanying table. The subject was then instructed to perform three-minute work intervals, followed by one minute of rest. During each work interval, the subject adjusted speed, incline, and resistance in order to achieve a maximal effort that could be sustained over the three-

minute period. The work/rest intervals were repeated three to five times, depending upon the subject's level of fatigue, and the test was stopped when the subjects felt they had reached a point at which they could not continue.

Level	Rating
1	I'm resting on the couch
2	I'm comfortable and could maintain this pace all day long
3	I'm still comfortable, but am breathing a bit harder
4	I'm sweating now, but feel good and can carry on a conversation effortlessly
5	I'm just above comfortable, am sweating more and can still talk easily
6	I can still talk, but am slightly breathless
7	I can continue at this pace with some discomfort, talking in short bursts
8	I can only nod in response to your questions and won't last long at this pace
9	I am very uncomfortable, losing focus and finding it almost impossible to continue
10	I physically cannot continue or I will surely collapse

During each rest interval the subjects were asked to rate their perceived exertion using a 10-centimeter visual analog scale (VAS), relatively based on the rating system described in the table. Because the devices employed in this study were variants of lower body exercise, however, it was necessary to distinguish between overall perceived exertion, and the perception of effort in only the legs. In this way, a more accurate index of heart rate, RPE, and exercise duration can be derived.

Accordingly, the VAS was used to measure perceived exertion of the legs (REP-L) and a separate, overall RPE (RPE-O). Scores were rounded off to the nearest half centimeter.

Lastly, heart rate and test duration were recorded with the Polar Team System.

Results

The heart rate response to the work interval is displayed in figure 1 at right. The repeated work bouts are clearly distinguished by the wavelike nature of the heart rate response. While the general trend of heart rate was similar for all of the devices, the absolute values between the devices, within each work interval, were different ($p < .05$), and the mean values, averaged across the work intervals, as seen in table 1, were also significantly different ($p < .05$).

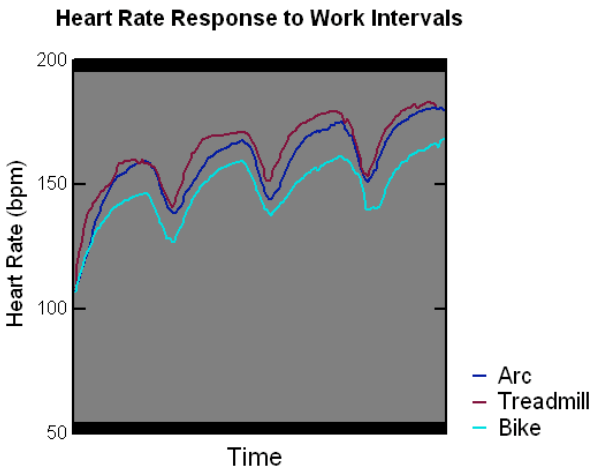

Figure 1.

Table 1 shows that the greatest mean heart rate was achieved on the treadmill. The Arc Trainer had the next highest heart rate, and the bike evoked the lowest heart rate response. On the other hand, table 1 also reveals that subjects could exercise longest on the Arc, while the treadmill produced the shortest exercise bouts.

Table 1. Heart Rate, RPE, and Duration of Exercise

	Heart Rate	RPE_L	RPE_O	Duration
Arc	156.74 ± 17.79	8.25 ± 1.06	9.15 ± 0.71	13.02 ± 2.27
Treadmill	161.07 ± 18.04	8.40 ± 1.08	9.55 ± 0.48	11.87 ± 2.37
Bike	145.75 ± 15.76	9.40 ± 0.52	7.20 ± 0.89	12.24 ± 3.09

Perceived exertion scores are also presented in the table, and shown graphically in the figure 2. Interestingly, the treadmill had the highest overall perceived exertion, followed by the Arc, and then the bike, which had a significantly lower overall RPE ($p < .05$). This may partially explain the finding that the treadmill had the shortest duration, but does not explain why the bike did not have the greatest duration.

Looking at the lower body RPE scores, on the other hand, the bike value of 9.4 was significantly higher than either the treadmill or Arc. This high perceived effort from the legs may inhibit subjects from working harder, and achieving higher heart rates.

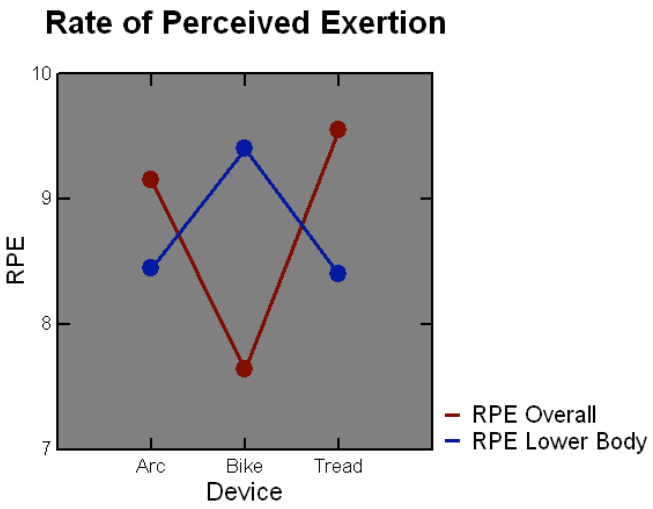

Figure 2.

It seems logical that the interaction of lower body RPE and overall RPE are related to heart rate and exercise duration. Accordingly, the following formula was developed in order to arrive at a cardio work index:

$$CWI = HR * Duration / RPE\_L \%$$

Where RPE_L % = RPE_L / RPE_O. The value is divided by 100 in order to arrive at a normalized score. This is presented graphically in the figure 3.

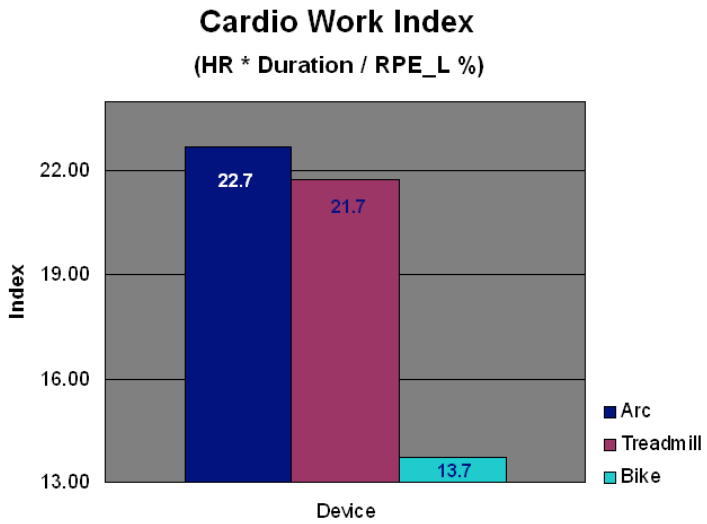

Figure 3.

Based on this index, the Arc Trainer produced a training effect that was slightly greater than the treadmill's. Both of these were substantially greater than the bike. It may be concluded then, that a device which yields the highest Cardio Work Index during high intensity interval training, will induce the optimal combination of heart rate and exercise duration, at the lowest perceived exertion. In this case, that device was the Cybex Arc Trainer.

Discussion

While high intensity interval protocols are potentially effective methods of exercise, their overall effect may be limited by a failure to achieve appropriately elevated heart rates, or by an inability to endure repeated work bouts.

Treadmills are typically considered the gold standard for interval work, largely because of the heart rate range that can be spanned on the device. The limitation to treadmills, on the other hand, may be the high overall perceived exertion, which ultimately reduces the total exercise time.

The Arc trainer, on the other hand, while producing a slightly lower heart rate than the treadmill, allows for extended exercise time, even at notably high hear rates, with less relative perceived effort. Also, unlike treadmills, or running in general, the Arc offers an impact free environment, with less overall stress and discomfort.

References

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