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Physiological Responses During A Modified Bruce Max Test In The Anti-Gravity Treadmill

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Abstract

INTRODUCTION: Physical activity can be difficult or painful for the obese, disabled, or those recovering from injury or surgery. For all populations, regular physical activity is a necessity for overall health, increased mobility, and reduction of all-cause mortality rates. Lower body positive pressure (LBPP) treadmills offer a way to unweigh users in an effort to reduce reaction forces that may inhibit physical activity and are less painful than traditional harness systems. To address this, the physiological responses in the AlterG© Anti-Gravity treadmill were measured, while performing a modified Bruce max test. The measurements take were the RPE, absolute and relative maximal oxygen consumption, heart rate, and respiratory exchange ratio of 3 males and 2 females during an exercise test using a modified Bruce protocol on at 100 and 70 percent body weight. The last variable measured was the time it took to get to maximal aerobic capacity.
PURPOSE: The purpose of this study was to determine whether there would be any significant differences in metabolic work to maximal aerobic capacity on an anti-gravity treadmill, using differential air pressure, at different percentages of body weight (100% and 70%). The null hypothesis is that there is no significant difference in physiological responses between different percentages of body weight as measured by RPE, absolute and relative maximal oxygen consumption, heart rate, and respiratory exchange ratio with the modified Bruce protocol.
METHODS: We had five subjects (age 24 ± 4) of two women and three males all from UTA. While subjects were tested on the LBPP treadmill their % body weight was at 70 and 100. Each subject performed a modified Bruce max test on the AlterG© treadmill. During each minute, absolute and relative maximal oxygen consumption (VO_{2max}), heart rate (HR), and respiratory exchange ratio (RER) was measured by the Cosmed K4b2 portable telemetric gas analysis system. After every stage, RPE was taken and then the time taken to maximal capacity. Each test was performed a week apart.
RESULTS: The maximal values: HR (100%: 186 ± 10.7 bpm; 70%: 185 ± 12.0 bpm); RPE (100%: 16.8 ± 1.1; 70%: 18.8 ± 1.1); VO_{2max} absolute (100%: 2.98 ± 0.7 L/min; 70%: 3.01 ±0.8 L/min); VO_{2max} relative (100%: 40.8 ± 5.3 ml/kg/min; 70%: 40.6 ± 6.1 ml/kg/min were not significantly different ($p > 0.05$). The average RER (100%: 1.04 ± 0.05; 70%: 0.98 ± 0.06) and the average time to get to max (100%: 13.6 ± 3.1 minutes; 70%: 24.2 ± 7.0 minutes) were statistically significant difference ($p < 0.05$).
CONCLUSION: The study revealed that there was a no significant difference in the maximal values of heart rate, RPE, and absolute and relative VO_{2max} on the AlterG© treadmills at different percentages of body weight. Removal of up to 30% bodyweight did not show to alter metabolic responses (VO2, HR, RER) during the modified Bruce protocol. Because the p-value was more than our alpha level of 0.05, the null hypothesis was accepted. Manipulation of body weight did not alter the contribution of the metabolically active muscle tissue required to maintain the forward velocity on the treadmill.

Background Information

Lower body positive pressure (LBPP) treadmills are used to reduce ground reaction and friction or forces, while maintaining cardiovascular stimuli associated with increased treadmill use (Grabowski and Kram 2008). An individual who is jogging can experience ground reaction forces (GRF) of up to three times their body weight with each heel strike of the running stride (Grabowski & Kram, 2008; Grabowski, 2010; Nilsson & Thorstenssen, 1989).The Alter G© allows for normal walking mechanics, which are critical for specificity of training, therefore it can be used for longer training sessions which are beneficial to neurological patients who show better improvement after mass practice and repetition. The Alter G© is also beneficial to patients who are participating in rehab after an injury or surgery as the differential air pressure can be used to unweight the patient and then progressively increase their load until they regain normal function (Lester et al 2011). Physiologically, the cardiovascular responses to exercising on an anti-gravity device have yet to be thoroughly explored. The purpose of this study was to measure maximal oxygen consumption (VO_{2max}), respiratory exchange ratio (RER), rating of perceived exertion (RPE), and HR response of subjects while jogging at 100% and 70% of their original body weight (BW).

Methods

- 5 UTA students participated in this study
- 3 males and 2 females
- No recent orthopedic injuries
- Clear medical history

- Instrumentation:
  Alter G© Anti-gravity Treadmill M/F 320, Polar Heart Rate Monitor, Cosmed K4b2 portable telemetric gas analysis system.
- Subjects were separated into 2 groups to avoid error due to order effect
- Heart rate, VO_{2max} absolute and relative, RER were collected at each minute of exercise
- RPE was collected after each stage and the time it took to max was also collected
- Alter-G preparation included fitting, prepping, calibration, and setting the body weight to 100% or 70% before conducting the test
- Subjects performed a Modified Bruce Protocol

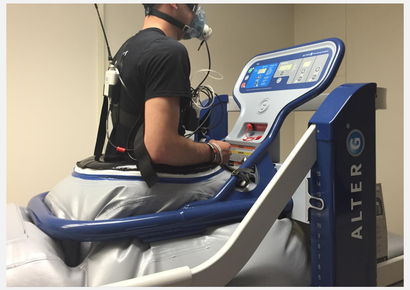

Table1: Modified Bruce Protocol

Stage	Speed	Grade %
1	1.7	10
2	2.5	12
3	3.4	14
4	4.2	15
5	5	15
6	5.5	15
7	5.8	15
8	6.2	15
9	6.5	15

Table 2: Demographic variables

Variable	Mean ± SD
Age (yrs)	24 ± 4.0
Height (m)	1.70 ± 0.1
Weight (kg)	73.5 ± 15.1

Results

Table 3: Performance Variables and P-values

	100% BW	70% BW	P-value
VO_{2max} (ml/kg/min)	40.8 ± 5.3	40.6 ± 6.1	0.93
VO_{2max} (L/min)	2.98 ± 0.7	3.01 ±0.8	0.73
HR max (bpm)	186 ± 10.7	185 ± 12.0	0.53
Time (min) to VO_{2max}	13.6 ± 3.1	24.2 ± 7.0	< 0.05
Average RER	1.04 ± 0.05	0.98 ± 0.06	< 0.05
RPE max	16.8 ± 1.1	18.8 ± 1.1	0.08

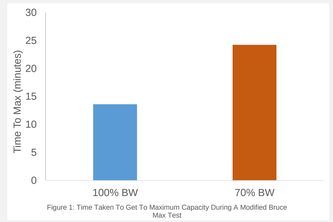

Figure 1: Time Taken To Get To Maximum Capacity During A Modified Bruce Max Test

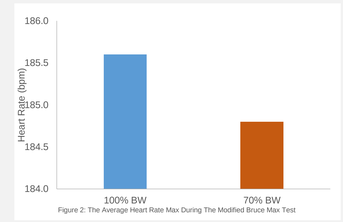

Figure 2: The Average Heart Rate Max During The Modified Bruce Max Test

Discussion & Conclusion

This study revealed that there is a no significant difference in the maximal values of heart rate, RPE, and absolute and relative VO_{2max} on the Alter G© treadmills at different percentages of body weight. Removal of up to 30% bodyweight did not show to alter metabolic responses (VO2, HR, RPE) during the modified Bruce protocol. The only significant factors are the time to maximal capacity and average RER. The significantly lower RER means the substrate utilization is significantly different at different body percentages. Manipulation of body weight did not alter the contribution of the metabolically active muscle tissue required to maintain the forward velocity on the treadmill. We recommend that the Alter G© be utilized in the clinical setting for rehabilitation and cardiovascular endurance for the extremely obese population. Further investigation utilizing this technology with exercise training protocols is warranted.