The Effects of Upper Body Arm Movement on Metabolic Rate in Lower Body Positive Pressure Treadmill Running

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Abstract

Lower body positive pressure (LBPP) treadmill running is being used more frequently in clinical and athletic settings. A previous study in the Exercise Physiology Lab determined metabolic rate (VO_2) on a LBPP and normal treadmill (NTM). Average (±SD) VO_2 at 5 and 6 mph on NTM was 2281.5±376.6 and 2609.5±427.4 ml $O_2 \cdot min^{-1}$. Average LBPP at 60% body weight resulted in a VO_2 of 1714.1±374.6 and 1913.2±478.8 ml $O_2 \cdot min^{-1}$ at the two treadmill speeds. Interestingly, the percent difference in metabolic rate was not proportional to the decrease in weight (~30% vs. 40%). We predict the ~10% difference in VO_2 is attributed to upper body arm movement on the LBPP treadmill. **PURPOSE:** The purpose of the study was to measure metabolic rate running on an Alter G (LBPP) treadmill with and without upper body arm movement. **METHODS:** Thirteen active, non-obese, college age participants completed two exercise tests of walking and running at 60% body weight on an Alter G treadmill and 100% body weight on a normal treadmill. The tests were: (a) walking for 2 min at 0.894 $m \cdot s^{-1}$ (2 mph), (b) running for 3 min at 2.24 $m \cdot s^{-1}$ (5 mph) and (c) running for 3 min at 2.68 $m \cdot s^{-1}$ (6 mph). The volunteers were tested once with normal arm swing and once with arms stationary. Oxygen consumption was measured using open flow indirect calorimetry and last thirty-second averages were defined as steady state. **RESULTS:** Volunteers' average (±SD) absolute VO_2 with arm use at 6 mph on the ATG with and without arms were 1866.0±550.5 and 1856.7±556.5 ml $O_2 \cdot min^{-1}$ respectively. Volunteers' average (±SD) absolute VO_2 at 6 mph on the NTM with and without arms were 2447.2±485.5 and 2517.3±575.5 respectively in ml $O_2 \cdot min^{-1}$. **CONCLUSION:** As predicted, absolute VO_2 was significantly less running on ATG yet there was no difference in VO_2 on the ATG with and without arms. Running on the ATG is less efficient as shown by no change in VO_2 with or without arm movement. This could account for the ~10% less metabolic rate of our previous study comparing LBPP and NTM.

Introduction

Exercising with a lower body weight can be a benefit for overweight or obese individuals and for rehabilitation of lower leg injuries (Eastlack et al. 2005). The Alter G treadmill uses lower body positive pressure (LBPP) to reduce the individuals' body weight. Recent results in our lab (Hupman et al, 2015) have shown that the decrease in oxygen consumption (VO_2) is not proportional to the decrease in body weight between LBPP treadmill and normal treadmill. Several factors may contribute to the greater VO_2 than expected at a reduced body weight such as running biomechanics and change in economy. Running with arm swing on a normal treadmill or track has been shown to reduce energetic cost as it provides biomechanical benefits (Umberger, 2008). Conversely, in the absence of arm swing, metabolic power demand and pelvic rotation increased (Arellano & Kram, 2014). Due to the unique arm position during running on the Alter G, we hypothesized that an exaggerated arm swing could be a cause of the greater metabolic cost of running on Alter G treadmill.

Purpose

The aim of this study was to determine the metabolic cost with and without arm swing running on a NTM and LBPP treadmill at 60% body weight. It was hypothesized that the less than proportional VO_2 between NTM and LBPP is due to unique arm swing used in LBPP running.

Methods

Thirteen active, non-obese, college age participants completed two exercise tests of walking and running at 60% body weight on an LBPP treadmill and NTM. The tests were:

(a) walking for 2 min at 0.894 $m \cdot s^{-1}$ (2 mph)
(b) running for 3 min at 2.24 $m \cdot s^{-1}$ (5 mph)
(c) running for 3 min at 2.68 $m \cdot s^{-1}$ (6 mph)
(d) The volunteers were tested once with normal arm swing and once with arms stationary.

Oxygen consumption was measured using open flow indirect calorimetry and last thirty-second averages were defined as steady state. Gross oxygen consumption was reported as ml $O_2 \cdot min^{-1}$.

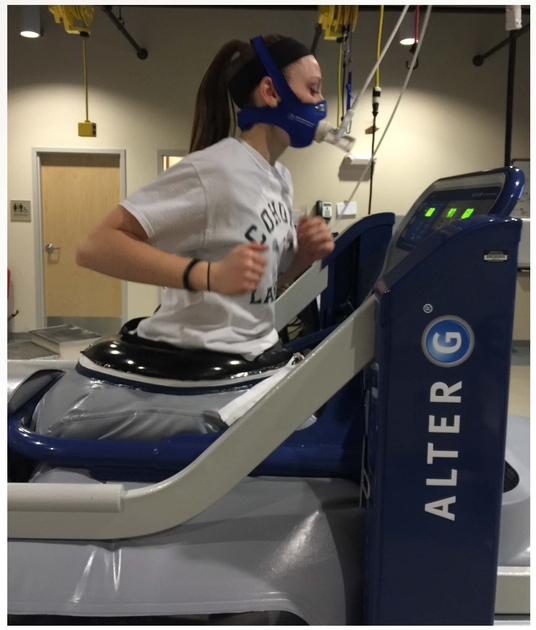

Figure 1. Picture of volunteer running on the Alter G (LBPP) treadmill with metabolic (VO_2) mask in place. Lower half of the treadmill is inflated with air to decrease body weight of the runner.

Results

Results of 3X ANOVA reported no statistically significant three-way interaction between treadmill, speed, and arm movement, $F(1,12) = 0.125$, $p = 0.730$. There was a statistically significant two-way treadmill*speed interaction, $F(1,12) = 15.793$, $p < .05$. Simple paired t-test comparing absolute VO_2 on normal treadmill at 5 mph with and without arms elicited a statistically significant increase in VO_2, $t(12) = 3.307$, $p < .05$. At 6 mph no significant differences in mean VO_2, $t(12) = 1.775$, $p = 0.10$. There were no significant differences in VO_2 and arm movement on ATG.

	AM	NAM
ATG 5mph	1727.5±481.5	1726.2±488.2
ATG 6mph	1866.0±550.5	1856.7±556.6
NTM 5mph*	2124.0±458.1	2222.2±477.6
NTM 6mph	2447.2±485.6	2517.3±575.4

Table 1. Average absolute VO_2 (±SD) (ml $O_2 \cdot min^{-1}$) running at 5 and 6 mph with arm movement (AM) and without arm movement (NAM) on the Alter G (ATG) and Normal Treadmill (NTM).
* indicates significant difference AM and NAM ($p < 0.05$).

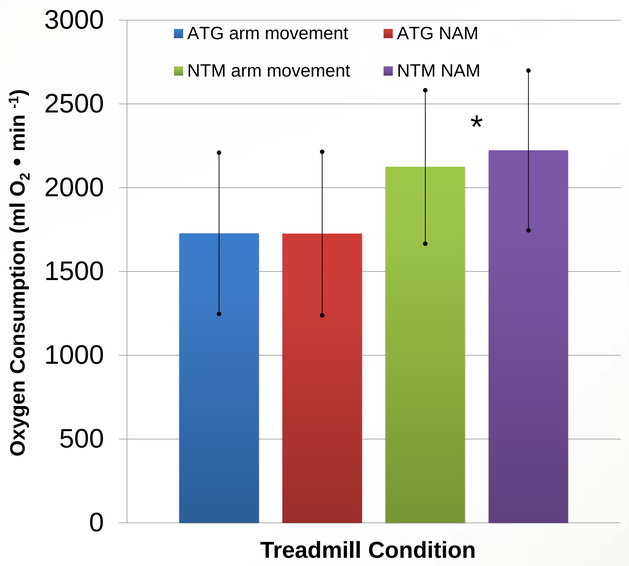

Figure 2. Average absolute metabolic rate (VO_2 in ml $O_2 \cdot min^{-1}$) running at 5 mph with arm movement (AM) and without arm movement (NAM) on the Alter G (ATG) and Normal Treadmill (NTM).
* indicates significant difference AM and NAM ($p < 0.05$).

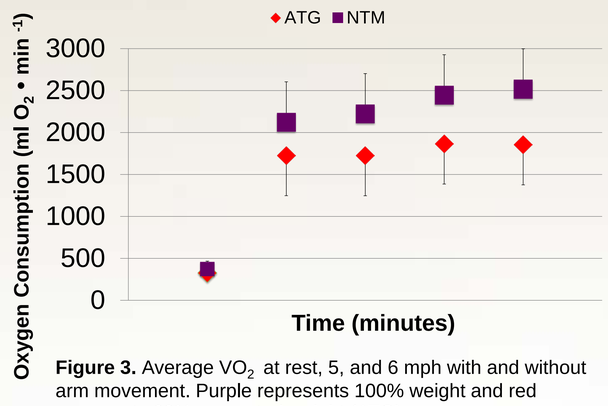

Figure 3. Average VO_2 at rest, 5, and 6 mph with and without arm movement. Purple represents 100% weight and red represents 60% supported weight (ATG).

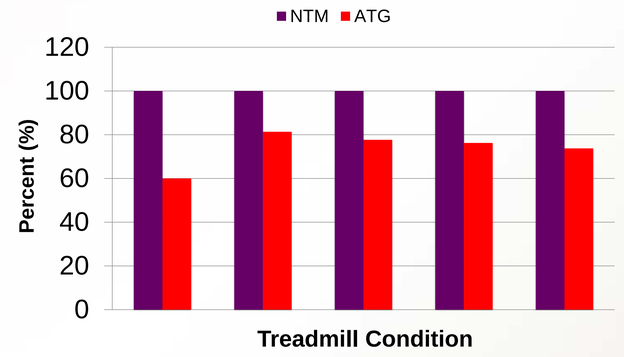

Figure 4. ATG conditions as a percent of normal treadmill. Treadmill conditions were body weight, 5 mph with AM and NAM, and 6 mph with AM and NAM. Purple represents 100% weight and red represents 60% supported weight (ATG).

Conclusion

Metabolic rate was greater with NAM while running on a normal treadmill yet not on the ATG. This indicates that arm movement is necessary to be biomechanically efficient while running. The findings on the ATG were contrary to our predictions as there were no significant changes in VO_2 with and without arm movement. Arm movement is required for normal running, suggesting that the ATG changes running biomechanics and decreases efficiency.

References

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