Energy Expenditure While Walking on a Non-Motorized Treadmill

Ann C. Snyder, CSCS*D, Christopher Myatt, Nathan Weiland, Joseph Bednarek and Kelly Reynolds
Department of Human Movement Sciences
Human Performance Laboratory
University of Wisconsin-Milwaukee, Milwaukee, WI, USA.

UNIVERSITY of WISCONSIN UW MILWAUKEE

UNIVERSITY OF WISCONSIN-MILWAUKEE HUMAN PERFORMANCE LAB Taking it to the Max

Abstract

Historically, non-motorized treadmills have been very large and required the stabilization of participants by either holding onto surrounding objects or wearing a harness during exercise sessions. Recently, smaller curved non-motorized treadmills have become available and are now being utilized in fitness centers. PURPOSE: To determine the physiological responses to walking on a curved non-motorized treadmill and to compare these responses to those of walking on a motorized treadmill. METHODS: Physically active, healthy college students (n=12, males = 7, females = 5) walked on the motorized (MT) and a curved non-motorized (CT) treadmills at 1.5, 2.5 and 3.5 miles·hour^{-1}. Each exercise bout lasted for 6 minutes. A 10 minute rest period occurred between exercises on each treadmill and all exercise bouts occurred on the same day. The order of use for the treadmills was randomized. All subjects had experience on both treadmills prior to any testing being performed. Heart rate (HR), oxygen uptake variables (VO_2, VE, RR, RER), muscle oxygenation (StO_2) and ratings of perceived exertion (RPE) during the last minute of each exercise bout were used for analysis. A two-way ANOVA with repeated measures was performed, followed by dependent t-tests where appropriate (*p<0.05). RESULTS: Oxygen uptake variables and HR were all significantly greater for the CT than for the MT (see table below). The RPE and StO_2 variables followed this trend, though not all of the differences were significant (table values in mean ± SD).

Variable	Treadmill	1.5 mph	2.5 mph	3.5 mph
VO_2 (ml·kg^{-1}·min^{-1})	MT	10.7 ± 2.0	13.8 ± 2.3	19.2 ± 3.9
	CT	13.6 ± 1.6*	19.5 ± 2.3*	26.1 ± 2.7*
HR (bpm)	MT	81 ± 8	88 ± 7	101 ± 8
	CT	90 ± 9*	104 ± 10*	120 ± 10*
RPE (0-10)	MT	0.5 ± 0.7	0.8 ± 0.8	1.7 ± 1.1
	CT	0.6 ± 0.9	1.3 ± 1.2*	2.0 ± 1.4
StO_2 (%)	MT	78 ± 13	79 ± 12	77 ± 12
	CT	73 ± 17	74 ± 17*	73 ± 15*

DISCUSSION: All subjects easily performed all speeds on the CT without the assistance of a harness or holding on. All speeds were easily walked, except the CT3.5, which resulted in a very fast walk that bordered on jogging. The increased physical effort, as indicated by higher VO_2 and HR values, while walking on the CT is probably due to the greater friction and/or increased muscle activation inherent with the use of a non-motorized treadmill. The results indicate that for those individuals who cannot attain desired increases in exercise intensity through jogging or running, significantly increased energy expenditure at the same speed and perceived exertion can occur while walking on the CT. PRACTICAL APPLICATION: The increased energy expenditure at each of the given walking speeds on the CT could have dramatic implications for populations that cannot achieve running speeds. For individuals whom are overweight, diseased or returning from injury, walking on the CT could allow the attainment of HR values similar to those achieved during running. The current study utilized a healthy, active population, but the results should be applicable to the aforementioned populations that cannot generally maintain running speeds for desired durations.

Introduction

With the dramatic increase in the prevalence of preventable diseases in our modern world, the maintenance of health and fitness is an ever growing concern in our society today. In order to combat recent increases in positive energy balance and preventable disease occurrence, scientists and manufacturers alike are continually developing new systems, techniques and equipment to improve the quality of exercise. Treadmills are currently one of the most popular techniques for performing aerobic exercise[1]. Traditionally, there have been two forms of flat treadmills available to consumers: non-motorized (NM) and motorized. In the past, NM treadmills were large and required users to wear a harness or to hold onto surrounding objects for force generation and/or stabilization during exercise. Recent technological innovations have allowed for the production of smaller, more practical NM treadmills that no longer require harnesses or supports to be utilized. These NM treadmills have become more readily available to the general public and are being utilized by fitness centers since they do not require electricity and are easy to use.

Currently, scientific knowledge is limited on the alteration of metabolic demand caused by NM treadmills and any differences between motorized and NM treadmills[2]. Research utilizing large NM treadmills has consistently shown increased energy expenditure versus that on motorized treadmills, even at walking speeds[1,2,3]. However, none of these studies have utilized small NM treadmills or typical walking speeds.

Purpose

To determine the physiological responses to walking on a small, curved non-motorized treadmill (CT) and to compare these responses to those of walking on a motorized treadmill.

Methods

- Subjects
  - 12 university aged participants (demographics in Table #1 below)
    - Male – 7 •Female – 5
  - Recruited based on activity level
    - All moderately active and perform regular aerobic exercise
- Procedures
  - Each subject walked for 3 stages at speeds of: 1.5, 2.5 and 3.5 miles·hour^{-1}
  - Exercises performed on two treadmills
    - NM curved treadmill (CT)
    - Motorized Treadmill (MT)
  - 10 minute rest period between exercise sessions on each treadmill
  - Treadmill order randomized
- Measurements
  - Heart Rate (HR) (Polar Electro, Finland)
  - Gastrocnemius oxygen saturation (StO_2) (Hutchinson Technology, USA)
  - Oxygen uptake variables (VO_2) by a mobile CPX system (MetaMax 3B, Cortex Biophysiks GmbH, Germany)
  - Average speed for each stage on the CT
- Statistical Analysis
  - HR, oxygen uptake (VO_2, VE, RR, RER), StO_2 and ratings of perceived exertion (RPE) during the last minute of each exercise bout used for analysis
  - Two-way repeated measures ANOVA
    - Paired t-tests when significance occurred
  - Significance set at p<.05

Table #1: Subject Demographics

Gender	Age	Height (in)	Weight (lbs)
Males	22.7 ± 2.4	69.5 ± 2.2	159.3 ± 13.7
Females	22.4 ± 1.7	64.4 ± 0.8	132.5 ± 8.7

Results

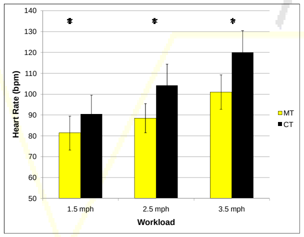

Figure 1. Heart rate

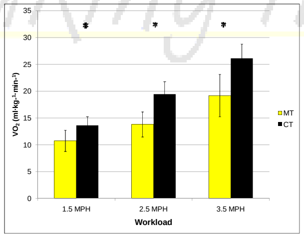

Figure 2. Oxygen Uptake

Results cont.

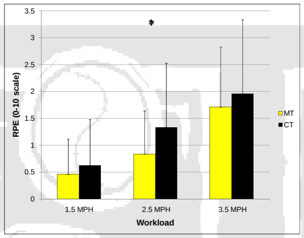

Figure 3. Rating of Perceived Exertion

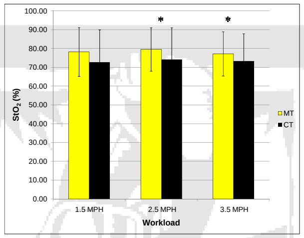

Figure 4. Muscle Oxygenation

Discussion

All subjects easily performed all speeds on the CT without the assistance of a harness or holding on to surrounding objects. All speeds were easily walked, except the CT3.5, which bordered on jogging, likely due to the momentum characteristics of the curved design. The increased physical effort, as indicated by higher VO_2 and HR values, while walking on the CT is likely due to the greater frictional characteristics, force generation requirements and/or increased muscle activation inherent with the use of a NM treadmill.

Practical Applications

The increased energy expenditure at each of the given walking speeds on the CT could have dramatic implications for general health and fitness populations. For individuals who cannot obtain desired energy expenditures through moderate to high levels of exercise intensity, such as overweight, diseased and rehabilitating individuals, exercise on newer CT could have dramatic implications. Walking on the CT could allow the attainment of HR values similar to those achieved during running. The current study utilized a healthy, active population, but the results should be applicable to the aforementioned populations that cannot generally maintain running speeds for desired durations.

References

1. De Witt, J., Lee, S., Wilson, C. A., & Hagan, R. D. (2009). Determinants of time to fatigue during nonmotorized treadmill exercise. *Journal of Strength & Conditioning Research, 23*(3), 883-890.
2. Hagan, R., De Witt, J., Laughlin, M., Lee, S., & Loehr, J. (2010). Motorized and Non-Motorized Treadmill Evaluation: Physiologic Responses and Biomechanical Aspects. NASA Special Report.
3. Otto, R., Wygand, J., Flanagan, K., Rowley, E., McPhilliamy, M., & Stewart, B. (1997). A Comparison of the Metabolic Response To Walking on Motorized and Non-Motorized Treadmills. *Medicine & Science in Sports & Exercise*, 29 (5), 203.