Physical Therapy in Sport 16 (2015) 262–267

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

Increased physiologic intensity during walking and running on a non-motorized, curved treadmill

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ARTICLE INFO

Article history:
Received 3 April 2014
Received in revised form
21 July 2014
Accepted 5 September 2014

Keywords:
Jogging
Energy expenditure
Woodway Curve
Oxygen consumption

ABSTRACT

Objective: To determine whether exercise performed on a non-motorized, curved treadmill (NMCT) provides greater physiologic stimulus compared to a standard motorized treadmill (SMT).
Study design: Crossover.
Setting: Clinical research laboratory.
Participants: 10 healthy athletic adults.
Main outcome measures: Participants walked (1.34 m s^{-1}) for 3 min and ran (2.24 m s^{-1}) for 4 min on NMCT and SMT (randomized order) while metabolic data and rating of perceived exertion (RPE) were collected. Participants then identified preferred easy and moderate intensity training paces on each treadmill while blinded to speed. Repeated-measures ANOVA and Wilcoxon Signed-Rank tests were used to compare responses between treadmills.
Results: Intensity was significantly greater ($P < 0.001$) for NMCT than SMT [mean (95% confidence interval): Walking = 5.9(5.3,6.4) vs. 3.4(3.0,3.7) METs; Running = 10.7(9,6,11.7) vs. 7.3(6.8,7.8) METs]. Overall RPE was significantly greater ($P < 0.01$) on NMCT than SMT for walking [median (inter-quartile range): 7(1) vs. 6(0.8)] and running [11.5(3) vs. 8(2.5)]. Preferred speed was significantly slower on NMCT than SMT for easy [2.5(2.3,2.7) vs. 2.8(2.5,3.1) m s^{-1}] and moderate [3.2(3.0,3.4) vs. 3.5(3.1,3.9) m s^{-1}] intensities.
Conclusions: NMCT elicits greater physiological stimulus than SMT with small, though statistically significant, changes in RPE at matched speeds. Clinicians must be aware of differences in intensity and RPE when prescribing exercise on NMCT.

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1. Introduction

Treadmills are a key piece of training equipment utilized by a diversity of populations, ranging from disabled patients undergoing rehabilitation to elite athletes aiming to maximize sports performance. Non-motorized treadmills allow users to naturally self-select speed and have demonstrated utility in fitness assessment (Janaudis-Ferreira, Sundelin, & Wadell, 2010), simulation of competitive sports (Sirotic & Coutts, 2008), and strength and conditioning (Highton, Lamb, Twist, & Nicholas, 2012). One recent innovation in non-motorized treadmill design has been a modified treadmill deck with a concave curved surface (Curve and Curve XL, Woodway USA Inc., Waukesha, WI). The non-motorized, curved treadmill (NMCT) is designed such that the user controls the treadmill belt speed dynamically, by changing where on the curved surface the user chooses to walk or run. The curved design introduces a slight incline to the front aspect of the treadmill creating not only the feeling of having to run uphill but also the need for greater speed to maintain the exact location on the treadmill. In theory, having to manually propel the treadmill belt especially on an incline creates a greater metabolic expenditure.

According to the treadmill manufacturer, exercise performed on NMCT can result in as much as a 30% increase in caloric expenditure compared to a standard motorized treadmill (SMT). This greater energy expenditure is important to quantify as an evidence-based practitioner looking to condition athletes as part of a comprehensive return to sport intervention. While the manufacturer provides two research abstracts on its website indicating greater physiologic intensity on NMCT compared to SMT (Snyder, Myatt, Weiland,

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http://dx.doi.org/10.1016/j.ptsp.2014.09.001
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Bednarek, & Reynolds, 2010; Snyder, Weiland, Myatt, Bednarek, & Reynolds, 2010), such claims are not accompanied by supporting peer-reviewed, published research. Previous research has evaluated NMCT for anaerobic performance (Gonzalez et al., 2013) and sprinting (Mangine et al., 2014). However, only one known peer-reviewed publication has investigated the use of such a treadmill for aerobic fitness, which reported a greater heart rate when the Rockport walk test was performed on NMCT compared to over-ground walking (Seneli, Ebersole, O'Connor, & Snyder, 2013). Additionally, this test, as performed on the NMCT, underestimated maximal oxygen consumption (Seneli et al., 2013) which suggests this unique treadmill design does elicit physiologic differences, but the extent of these differences is currently not known.

Given the potential for NMCT to increase metabolic demand during exercise, we aimed to compare cardiometabolic responses and rating of perceived exertion (RPE) of healthy subjects between NMCT and SMT during walking and running. We hypothesized that at a matched speed, subjects exercising on NMCT would experience greater metabolic demand compared to SMT for both walking and running.

2. Materials and methods

2.1. Subjects

A heterogeneous group of healthy recreationally active (e.g. general fitness participants) and competitive (e.g. lacrosse players, cyclists, track and field athletes) individuals, ages 18 through 50 years, were recruited from the university community to participate in this study. Ten participants (5 male and 5 female) were enrolled in this study and all completed the study (Age = 28.1 ± 9.8 y; Height = 1.77 ± 0.13 m; Mass = 70.3 ± 12.4 kg; BMI = 22.3 ± 2.3 kg m^{-2}). All subjects underwent written informed consent, which was approved by the university's Institutional Review Board. Individuals with a history of recent musculoskeletal injury, neuromuscular, metabolic, or cardiopulmonary diseases which would alter walking and running performance were excluded from participation.

2.2. Testing procedures

Subjects completed one testing session within the laboratory. Two treadmills were utilized for this study: 1) SMT: a standard motorized treadmill (ELG, Woodway, Waukesha, WI) and 2) NMCT: a non-motorized treadmill with a curved running surface (Curve XL, Woodway, Waukesha, WI). Both treadmills were factory calibrated and were properly installed by a representative from the manufacturer.

2.2.1. Metabolic measurements

Subjects were fitted with a portable metabolic measurement system (Jaeger Oxycon Mobile, CareFusion, Yorba Linda, CA). The metabolic system was calibrated in accordance with manufacturer's directions prior to each subject's test. Breath-by-breath data were recorded and stored on a laptop computer. The beginning and end of each stage of the exercise protocol was marked within the system's software. Oxygen uptake (raw VO_2: L O_2 min^{-1}; and METs: 1 MET = 3.5 mL O_2 kg^{-1} min^{-1}), heart rate (HR), and estimated energy expenditure (EE) served as dependent variables representative of physiologic intensity.

2.2.2. Exercise protocol

The exercise protocol is summarized in Fig. 1. Subjects rested while in a seated position for 5 min for baseline measurements to be recorded. A baseline lactate sample was collected using a finger prick and analyzed using a validated portable lactate meter (Lactate Pro, Nova Biomedical). Prior to all lactate samples, the finger was cleaned using a moistened paper towel and then dried with a dry paper towel to ensure sweat did not contaminate the blood sample.

Following the baseline measurements, subjects began the exercise protocol. The order of treadmill conditions was randomized using a computerized random number generator. Subjects walked on the first treadmill for 3 min at 1.34 m s^{-1} (3.0 mi h^{-1}). A 2 min standing rest was then provided. Subjects then ran at 2.24 m s^{-1} (5.0 mi h^{-1}) for 4 min. For NMCT, subjects were instructed to continually monitor their speed on the LCD screen and maintain it as close to the prescribed speed as possible verbal cues to do so were provided if necessary. Pilot testing revealed the chosen exercise bout durations provided sufficient time to achieve a metabolic steady state for at least 1 min before the end of the exercise stage. Subjects were then provided 5 min of seated rest before repeating these procedures on the second treadmill. A blood lactate sample was collected approximately 45 s before the end of the recovery duration.

For both running and walking, ratings of perceived exertions (RPE) for the legs, breathing, and overall body were collected by having subjects point to a standard Borg scale (scale range: 6–20). RPE data were collected within the last 15 s of each exercise period for each condition. Immediately following the end of each exercise stage, a blood lactate sample was collected and analyzed.

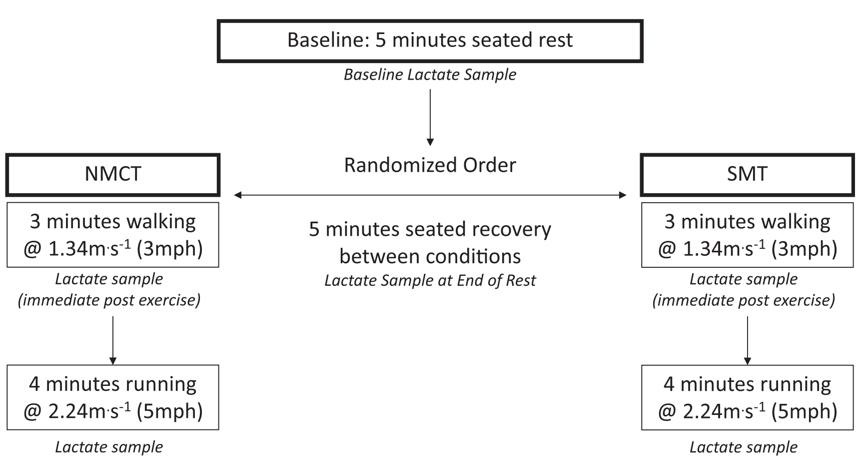

Fig. 1. Study design. Metabolic data were monitored continuously throughout and RPE were recorded during the last 20 s of each stage.

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