Foot Pressures of Walking, Jogging, and Running on Non-Motorized and Motorized Treadmills

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Abstract

Motorized and non-motorized treadmills are now available for athletic preparation and/or fitness activities. The main difference between the exercises performed on the treadmills is that on the non-motorized treadmill the exerciser propels the treadmill belt in order for the exercise to be performed. **PURPOSE:** The purpose of this study was to examine rear foot and fore foot pressures to determine if the pressures upon the foot changed with the use of different types of treadmills. **METHODS:** Eleven healthy college-aged individuals (6 males and 5 females) walked at 1.34 m/s, jogged at 2.23 m/s, and ran at 3.13 m/s on three different treadmills; two motorized, a belt driven (BT) and a slatted (ST), and a non-motorized treadmill (CT). Foot pressures were measured using Tekscan shoe inserts (Tekscan, South Boston, MA) and were recorded for 10 seconds after performing the speed for approximately one minute at the prescribed speed. The three speeds were performed sequentially on each treadmill, but the order of treadmill usage was randomized. Statistical analysis was performed using repeated measures ANOVA with a post hoc Tukey test to determine where significant differences occurred ($P<0.05$). **RESULTS:** Fore-foot pressures were not different between the three treadmills for the three speeds assessed. Rear foot pressures were significantly less on the CT than for the two motorized treadmills at all three speeds.

	1.34 m·s^{-1}			2.23 m·s^{-1}			3.13 m·s^{-1}		
	BT	ST	CT	BT	ST	CT	BT	ST	CT
Rear-foot (kPa)	176.2 ±31.5	175.7 ±26.0	133.9* ±44.0	139.4 ±49.3	159.7 ±42.0	72.9*^ ±40.3	176.8 ±60.7	200.5 ±52.6	83.3*^ ±36.5
Fore-foot (kPa)	276.6 ±66.1	270.5 ±69.0	247.0 ±51.7	331.6 ±90.3	318.2 ±74.9	311.4 ±93.1	366.2 ±101.7	353.5 ±88.2	347.1 ±115.1

* = p < 0.05 between both BT and ST at given speed ^ = p < 0.05 between 1.34 m·s^{-1}

CONCLUSIONS: Walking and running on the CT resulted in lower pressures in the rear foot than occurred on the motorized treadmills. Whether this is due to the construction of this particular CT or to the general activity required of non-motorized treadmills remains to be investigated.

Introduction

Treadmills are currently one of the most popular pieces of exercise equipment for performing aerobic exercise[1]. Traditionally, there have been two forms of flat treadmills available to consumers: motorized and non-motorized (NMT). Flat NMTs require the user to either wear a harness or hold onto a railing to provide stability when generating movement. NMTs have become commercially available to the general public and are popular in fitness centers since they do not require electricity and are easy to use. While NMTs are more readily available, there is a lack of scientific research into the biomechanical and physiological differences exhibited between them and motorized treadmills. Currently, scientific knowledge is limited on the alteration of the biomechanical gait patterns exhibited on NMTs[2]. Recent technological innovations have allowed for the production of a smaller, curved NMT (CT) that does not require the use of a harness or a support rail.

Since the popularization of the modern running shoe in the 1970s, runners have displayed a primarily rear-foot landing pattern, due to increased heel cushioning in many running shoes[3]. Interestingly, a dramatic increase in running injuries has been seen concurrently with the rise in utilization of modern running shoes.[3] Fore-foot running has recently emerged as a hot topic in the running community, due to the hypothesis that it could prevent many of the high-impact injuries commonly seen in many runners[3]. It was our hypothesis that the curved nature of the CT would require users to utilize a primarily fore-foot running strategy, thus reducing rear-foot pressures. This is of practical interest as a decreased loading on the rear-foot might decrease the prevalence of high-impact, overuse injuries.

Purpose

To determine whether foot pressures vary between different forms of treadmills, through the examination of fore-foot and rear-foot pressures.

Methods

Subjects

- 11 university-aged participants (male = 6) (see Table 1)
- All moderately active and performing regular running exercise

Procedures

- Participants wore an insertable foot pressure sensor (Tekscan shoe inserts; Tekscan, South Boston, MA) between their sock and the insole of their right shoe .
- Each participant performed 3 sequential trials on 3 types of treadmills in a randomized order at speeds of: 1.34, 2.23 and 3.13 meters·second^{-1}
- Three treadmill types:
  - Non-motorized curved treadmill (CT)
  - Motorized slatted treadmill (ST)
  - Motorized belt driven treadmill (BT)

Data

- Foot pressure
  - Collected for 10 second after a 1 minute speed acclimation period.
  - Average rear-foot and fore-foot pressures were calculated
  - The peak pressure and the three adjacent cells in the rear- and fore-foot regions were averaged to determine the average peak pressure, respectively
  - Data collected at 100 Hz
- CT Speed
  - Average speed for each stage on the CT measured
  - CT trials accepted within ±0.09 m·s^{-1} of target speed

Statistical Analysis

- Two-way repeated measures ANOVA was run
- Post-hoc Tukey HSD tests were performed to determine if significant differences existed between types of treadmills at the same speed
- Significance set at $p<.05$

Table 1: Subject Characteristics

Gender	Age (yr)	Height (in)	Weight (lb)
Males	23.2.± 1.5	178.6 ± 6.9	77.0 ± 13.0
Females	25.2 ± 2.6	161.8 ± 4.1	56.8 ± 5.1

Results

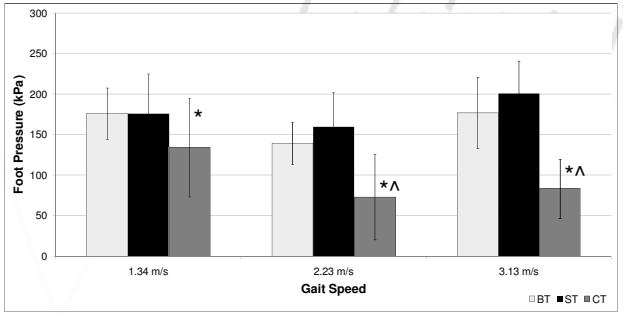

Figure 1. Rear-Foot Pressures
* significantly different ($p<0.05$) compared to BT & ST at the same speed
^ significantly different ($p<0.05$) compared to 1.34 m·s^{-1} at same condition

Results (cont.)

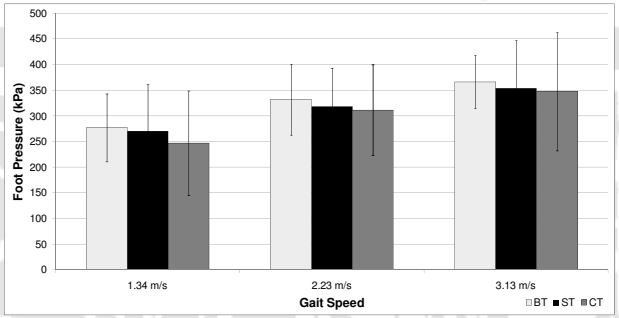

Figure 2. Fore-Foot Pressures
* significantly different ($p<0.05$) compared to BT & ST at the same speed

Discussion

Rear-foot pressures were shown to be significantly less on the CT at all speeds, in comparison to the two motorized treadmills. Fore-foot pressures were not found to be significantly different amongst the three treadmills at any of the three speeds. As hypothesized, rear-foot pressures were decreased on the CT, which was more pronounced during jogging and running versus walking. As forefoot pressures on the CT did not change, the running style utilized did not lead to a greater overall fore-foot stress. It remains to be determined whether this finding is the result of the unique construction of this CT, or whether this is a functional requirement for locomotion on NMTs in general.

Future Directions

Further research is needed into the biomechanical and physiological alterations exhibited during use of NM treadmills. Future studies should look at not only kinetic differences, but also the kinematic changes caused by NMTs. Additionally, evaluation of muscle EMG should be performed to determine if there is a difference in muscular utilization during locomotion on different NMTs. As the CT has been shown to produce less rear-foot pressure, a longitudinal study to determine if NMTs can lead to changes in running gait might be useful.

References

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3. Lieberman DE, M Venkadesan, WA Werbel, AI Daoud, and S D'Andrea. Foot strike patterns and collision forces in habitually barefoot versus shod runners. *Nature*, 463: 531-535, 2010.