Heart Rate Response during Treadmill Running in adidas_1 DLX™ Computerized Running Shoes at Various Shoe Settings

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ABSTRACT

BACKGROUND: Runners encounter a wide variety of terrains of varying hardness which can be modified by midsole cushioning. Cushioned shoes are recommended for athletes to decrease impact forces. The adidas_1 DLX shoe is advertised as being able to provide appropriate cushioning levels for different athletes on different terrains.
PURPOSE: The purpose of the experiment was to investigate the effects of a commercially available computerized running shoe (adidas_1 DLX™) on heart rate and feelings of foot comfort. The data collected will be used to validate or refute some of the manufacturer's claims, and make recommendations to consumers about these types of shoes.
HYPOTHESES: We hypothesized that the different settings on the adidas_1 DLX™ shoe would influence heart rate and subjective foot comfort ratings.
METHODS: Nine males (23 ± 3.6 yrs) ran 4 10-minute trials on a treadmill at a fixed speed, once in their own self-selected shoes and three times in the adidas_1DLX™ shoes at automatic, manual hard, or manual soft settings. Heart rate was measured at 5, 7.5, and 10 minutes. Foot comfort was measured immediately after each trial.
RESULTS: Shoe comfort ratings for all adidas_1 DLX™ settings were approximately 30% lower compared to self-selected shoes. There was no statistically-significant difference in heart rate between the trials.
CONCLUSIONS: Mid-sole cushioning influences the comfort felt by runners. The data showed no significant relationship between mid-sole cushioning and heart rate, but did show that runners felt more comfortable in their own self-selected shoes versus the adidas_1 DLX™ shoes at any setting.

INTRODUCTION & HYPOTHESES

Running involves moving in a "bouncing" fashion along the ground; energy is constantly stored and returned by the musculoskeletal system. Runners encounter a wide variety of terrains of varying hardness which can be compensated for or added to by midsole cushioning.[1] Cushioned shoes are recommended for athletes to decrease impact forces at the heel or on the feet in general (a phenomenon known as impact attenuation). These recommendations need to be tempered by the knowledge that although direct impact forces on the heel or foot may decrease, limb stiffness may increase.[3]

In many cases it is the mid-sole cushioning that determines comfort level. In the field of comfort and shoe design much research has determined that cushioning in the shoe is not strongly correlated to reducing injuries, but the cushioning as well as the specific phase of running stride will relate back to comfort. The goal of this study was to determine how the different settings on the adidas_1 DLX shoe influenced heart rate and perceptions of comfort.[2] This shoe model is purported to "understand that your needs change when you move faster or slower or when the ground gets harder or softer beneath your feet. And it continually adapts its cushioning to give you your perfect level of comfort and performance at all times."[4] The various settings are achieved by changing tension in a steel cable that runs from rear to mid foot. While in the automatic setting, an accelerometer (computer that measures impact forces) within the heel adjusts tension on the cable via a motor located in the midsole compartment to minimize impact forces.

We hypothesized that the different settings on the adidas_1 DLX™ shoe would influence heart rate and comfort ratings. Specifically, we believed that the hard setting of the adidas_1 DLX™ shoe would cause an increase in heart rate and a decrease in comfort levels as compared to the same shoe in soft or automatic settings or the self-selected shoes.

METHODS:

Subjects: Approval was granted by Drake IRB to conduct this research under IRB2007-08106. The study included 9 male volunteers (age = 23 ± 3.6 yrs, weight = 76.7 ± 8.6 kg, height = 180.6 ± 3.3 kg; all mean ± SD). The subjects were considered fit and able to run safely at a moderate intensity for four intervals of ten minutes based on a medical history questionnaire. The mean resting heart rate of the group was 66 ± 6.6 beats per minute (bpm). All subjects pictured in this poster gave written permission to public presentation of their image via an IRB-approved document.
Equipment: Subjects brought their own preferred pair of running shoes to the lab for part of the study (Table 1). The adidas_1 DLX™ shoe (adidas Group, Portland, OR) was used at the soft, hard, and automatic settings. Because all subjects were running in the same adidas_1 DLX™ shoes, subjects were given a new pair of socks (adidas ClimaCool crew cut) in between running in their own shoes and running in the test shoes. Heart rate was measured using a Polar F6M (Polar Electro Oy, Kemple, Finland) chest strap monitor that was radio-linked to a receiver watch. A Sole TT8 motorized treadmill (SOLE Fitness, Jonesboro, AR) was used.
Experimental Design: For the first 10 minute run the subjects ran in their own running shoes. After 5 minutes when steady state has been reached, a treadmill speed was chosen for each subject individually during the trial such that their heart rate was 140 2 beats per minute. This treadmill speed was then fixed for the three subsequent trials, which were randomized and consisted of running in adidas_1 DLX™ shoes at hard, soft, or automatic setting. Subjects were given a 10 minute seated recovery period in between trials.
Data Collection and Analysis: The heart rate receiver watch was held by an experimenter within a two foot radius of the running subject. Measurements were collected at 5,7.5, and 10 minutes of running in each trial. ANOVA was used to compare main effects of shoe setting and time point on heart rate. At the end of each trial, volunteers were asked to rate the shoe by drawing an "X" on a 6-inch line where "uncomfortable" was written on the left and "comfortable" was written on the right. Subsequently, the distance along the continuum was measured and the values compared statistically via T-test.

TABLE 1. Shoe Attributes. Make, model, training type, and weight of runners' self-selected shoes as compared to adidas_1 DLX™ (in red). Shoes are ordered by descending weight in grams.

Make	Model	Training Type	Weight (g)
Adidas	Kevin Garnet Series_2005	basketball	498.3
Adidas	adidas_1 DLX™		457.6
Nike	Shox QS2	cross-training	456.4
Asics	Gel Cumulus 9	running-cushioning	430.49
New Balance	882	running-motion control	390.8
Asics	Gel Cumulus 9	running-cushioning	377.6
Nike	ACG Trail Alvord Series	running-trail	371.2
Asics	Gel Kanbarra 3	running-stability	360.9
Mizuno	Weight Precision 9	running-cushioning	320.8
Nike	Zoom PV Lite	running-performance	258.2

FIGURE 1. adidas_1 DLX™. (a) Side view showing cable running from heel to midfoot. (b) Bottom view, showing cable motor. (c) Experiment in progress.

FIGURE 2. Shoe Comfort Ratings. Subjective feelings of comfort were measured on a 15 cm continuum, with "0" representing "very uncomfortable" and 15 representing "very comfortable." The asterisk represents a significantly higher rating of comfort (p=0.04) in the self-selected shoes vs. the adidas_1 DLX™ at any setting.

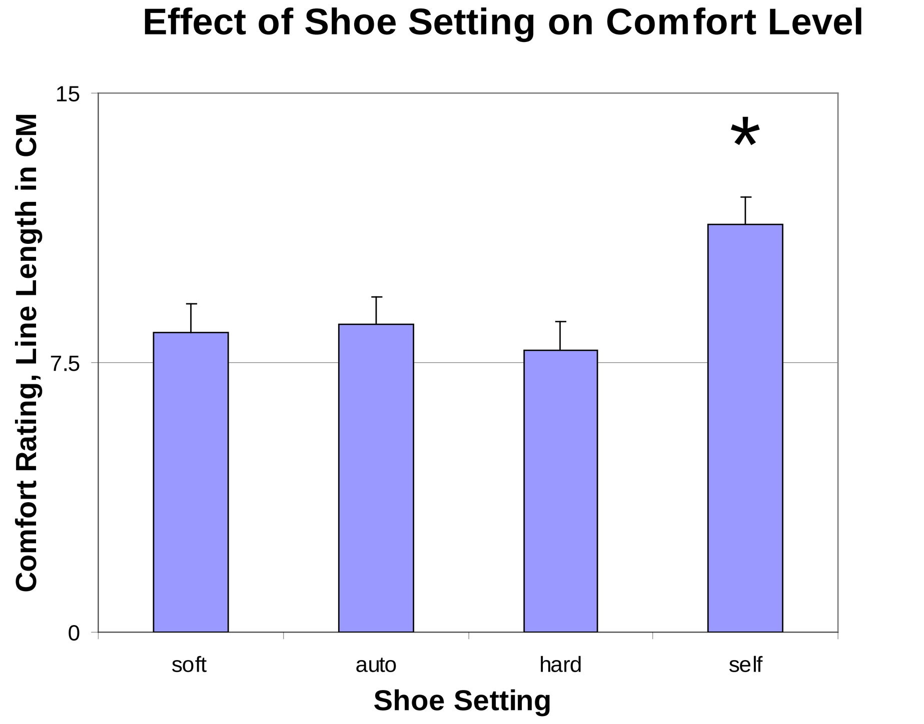

FIGURE 3. Heart Rate Response. Heart rate (in beats per minute) at 5, 7.5, and 10 min into each of the four trials. There were no statistically significant differences between trials, though heart rate did increase with time across all trials (p=0.090).

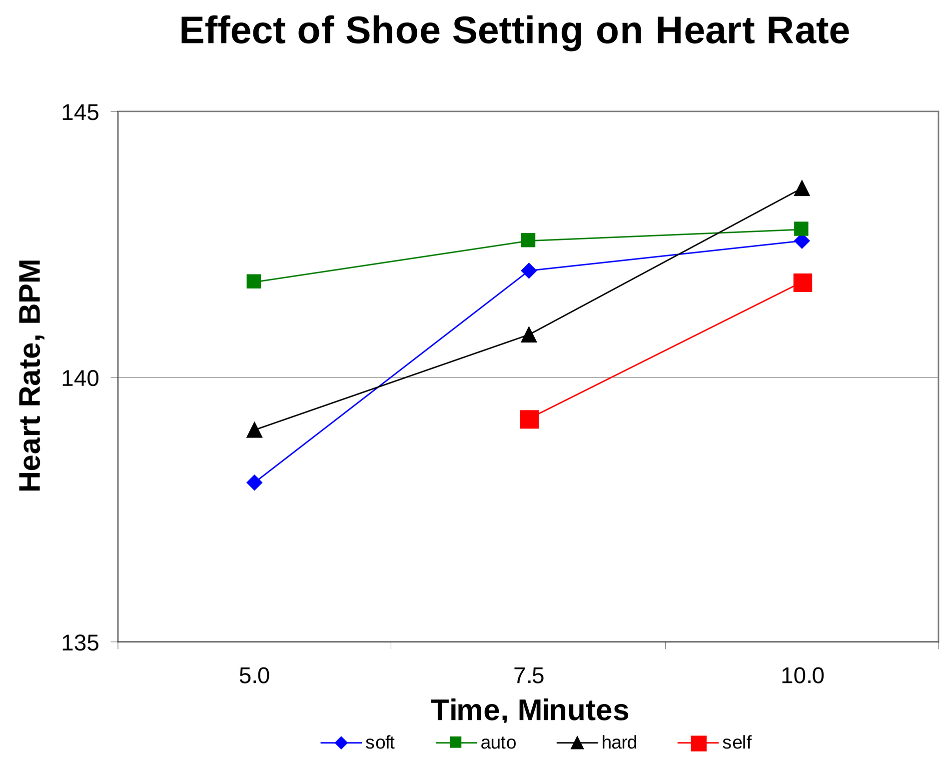

TABLE 2. Heart Rate ANOVA. Tests of Between-Subjects Effects. Statistical analysis looking at main effects of shoe setting ("shoecode") or time ("hrtime"), and interactions between those factors, on the dependent variable of heart rate.

Tests of Between-Subjects Effects

Dependent Variable: hr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	323.733[a]	10	32.373	1.024	.430
Intercept	1944564.293	1	1944564.293	61496.028	.000
shoecode	100.578	3	33.526	1.060	.370
hrtime	156.313	2	78.157	2.472	.090
shoecode * hrtime	97.543	5	19.509	.617	.687
Error	2814.267	89	31.621		
Total	2002534.000	100			
Corrected Total	3138.000	99			

a. R Squared = .103 (Adjusted R Squared = .002)

RESULTS

TABLE 1: The adidas_1 DLX™ shoes were heavier than most pairs of shoes self-selected by the runners in our study; the one exception occurred in a runner who preferred basketball shoes for training over running shoes. Subjects ran in a variety of different types of running footwear designed for different environmental and competition conditions.

FIGURE 2: T-tests revealed that subjective ratings of shoe comfort were statistically significantly higher when runners were running in their own self-selected shoes versus the adidas_1 DLX™ shoes in any setting (p=0.04).

TABLE 2: There was no significant effect of shoe type/setting on heart rate as determined by ANOVA (p=0.370). There was a trend towards significance for an effect of time on heart rate (p=.090), such that heart rate increased towards the end of each running trial.

FIGURE 3: Though not statistically significant, heart rate in self-selected shoes was lower than heart rate in adidas_1 DLX™ shoes at all time points. Due to the need to adjust treadmill speed for consistent heart rates across participants, data was not recorded at the 5-min time point in the self-selected shoe trial.

DISCUSSION & CONCLUSIONS

Our hypothesis was that the hard setting of the adidas_1 DLX™ shoe would increase heart rate and decrease shoe comfort rating as compared to other shoe settings or self-selected shoes. Our results support our hypothesis on shoe comfort, but reject our hypothesis on heart rate. They suggest that, for the adidas_1 DLX™ shoe at least, the change in cable tension across shoe settings is sufficient to alter an individual's perception of shoe comfort, but not their body's physiological response during running as represented by heart rate. Most subjects could correctly identify the trial during which the adidas_1 DLX™ shoe was set on the hard setting when asked casually after the experiment, but could not discriminate between the soft and automatic settings. Because all subjects were running in an identical pair of socks while wearing the adidas_1 DLX™ shoes, there were no differences in fabric between foot and shoe, eliminating the sock as a confounding variable in perceptions of comfort between subjects. The sheer weight of the adidas_1 DLX™ shoes as compared to self-selected shoes may explain some of the differences here, as the experimental shoes were heavier than most of the self-selected shoes.

This questions the link between comfort and heart rate. One might guess that with increased comfort, heart rate would correspondingly decrease due to the fact the body would not have to work as hard if it was more content. The connection between comfort influencing heart rate may be an area of further study. Another possible explanation for the results may be because there is not a significant difference between the shoe settings: if the shoe was not changing significantly, there might be no change in the heart rate between the trials. The topic could be investigated further by recruiting more subjects and additional running trials with different shoe sizes, genders, and levels of personal fitness. Though we tried to find subjects that were all moderately active, trained runners and recreational runners may define comfort in a different sense and thus produce different data.

Overall there are many things that we would like to change about the study. This may be corrected by running more trials, running trials with more subjects, varying gender and different shoes sizes. As well we may want to test between trained runners and recreational runners.

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