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™ would influence heart rate and subjective foot comfort ratings.

METHODS: Nine males (23 ± 3.6 yrs) ran 4-10 min trials on a treadmill at a fixed speed, once in their own self-selected shoes and three times in the adidas 1 DLX™ 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 the 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: Midsole cushioning influences the comfort felt by runners. The data showed no significant relationship between midsole cushioning and heart rate, but data 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 to decrease direct impact forces on the heel or foot 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.2

In many cases it is the midsole cushioning that determines the comfort level. In the comfort of the foot and shoe design and function. Researchers have found that cushioning in the shoe is strongly correlated to reduced injuries, but the cushioning as well as the specific phase of running order may vary.1 The goal of our study was to examine the effect of cushioning on the adidas 1 DLX shoe influenced heart rate and perceptions of comfort.3

This 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 foot. And it continually adapts its cushioning to give you your very best level of comfort and performance at all times.1" The hypothesis is that with increasing hardness, the midsole will change in density in a steady cycle that runs from near to mid foot. While in the automatic setting, an accelerometer (computer that measures impact forces) within the heel adjusts the tension on the cable in the midsole 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: The experiment was granted by Drake IRB to conduct this research under IRB2007-0108. The study included 9 male volunteers (age = 23 ± 3.6 yrs, weight = 76 ± 8.7 kg, height = 180 ± 3.2 cm) in good health. The Institutional Review Board at Drake University approved the study and all individuals participating in this study were informed of potential risks and benefits associated with the study. Written informed consent was obtained from each volunteer prior to the experiment.

Equipment: Subjects brought their own preferred pair of running shoes to the lab for the part of the study (Table 1). The adidas 1 DLX™ shoe (adidas Group, Portland, OR) was used in the soft, hand- and automatic settings. Because all subjects were running in the same shoe, we believe that any differences between the trials were due to the intervention. Subjects were instructed to wear the same sock in each trial. All subjects were instructed to run barefoot (no shoes, no socks) with their normal running gait and unique footfall pattern.

Experimental Design: Subjects were run 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 so 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 recorded was held by an experimenter within a 2-foot radius of the running subject. Measurements were collected at 5.75, and 10 minutes of running in each condition. 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 to T-test.

RESULTS
TABLE 1. Shoe Attributes. Make, model, training type, and weight of runners’ self-selected and adidas 1 DLX™ (n=40). Shoes are ordered by descending weight in grams.

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Training Type</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Show GSQ</td>
<td>cross-training</td>
<td>419.4</td>
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<tr>
<td>New Balance</td>
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<td>running-motion-control</td>
<td>430.6</td>
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<td>running-trail</td>
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</tbody>
</table>

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. Shoef Comfort Ratings. Subjective feelings of comfort were measured on a 15 cm continuum, with “1” representing “very uncomfortable” and “15” representing “very comfortable.” A high score represents a significantly higher rating of comfort (p=0.01) 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=0.050).

CONCLUSIONS: Midsole cushioning influences the comfort felt by runners. The data showed no significant relationship between midsole cushioning and heart rate, but data that runners felt more comfortable in their own self-selected shoes versus the adidas 1 DLX™ shoes at any setting.

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. One might compare this hypothesis on shoe comfort, but reject our hypothesis on heart rate. They suggested that, for the adidas 1 DLX™ shoe at least, the change in cable tension across shoe settings is sufficient to alert an individual’s perception of shoe comfort, but not lead to a physiological response during running as represented by heart rate. Most subjects could correctly identify the shoe during which the adidas 1 DLX™ shoe was on the hard setting when asked casually after the experiment, but could not distinguish between the soft and automatic settings. Because all subjects were running in an identical pair of shoes while wearing the adidas 1 DLX™ shoes, there were no differences in fabric between foot and shoe, eliminating the risk as a confounding variable in perceptions of comfort between subjects. The sheer weight of the adidas 1 DLX™ shoes 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 a topic for further research. Another possible explanation for the results may be that there is 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 similarly 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 age groups. We hope that this study may be used to aid in training or recreational runners.

REFERENCES
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ACKNOWLEDGMENTS
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