SHOCK ABSORPTION CHARACTERISTICS OF FOOTWEAR WORN BY AEROBIC INSTRUCTORS

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Aerobic exercise is one of the most popular forms of cardiovascular exercise among women. Numerous studies have documented the high incident of lower extremity injury among aerobics instructors. Factors contributing to the high incidence of injuries include, type of floor, overuse, falls and shoes. Aerobic instructors have identified their shoes as the second possible cause of injuries (Davis and Bahamonde, 2000). Eleven aerobic instructors were given two popular brand name of aerobic shoes. The shock absorption of the shoes were tested after a determined number of hours of use. Tests were done at heel and toe box and with and without the insole.

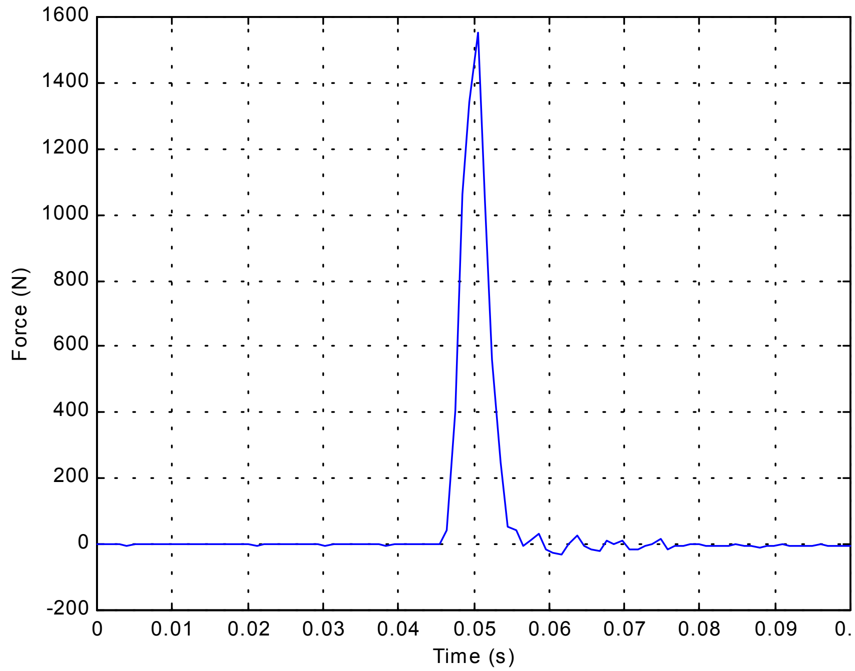
KEY WORDS: aerobic shoes, shock, absorption, injuries

INTRODUCTION: Aerobics has become one of the most popular forms of exercise. Aerobic dance is one of the largest organized activities primarily for women in the United States (Garrick, 1986). The increased popularity seems to go hand-in-hand with the increases in the prevalence of injuries. Numerous studies have been done concerning the origin of injuries suffered by those who participate in aerobics. The studies have found that a majority of the injuries occur in the lower extremities, with 82% of 24 aerobic instructors having suffered injuries to the lower extremities (Vetter, 1985). Furthermore, in an earlier survey of 135 instructors it was shown that 76.3% of instructors had sustained or aggravated one or more injuries from aerobic dance (Francis, 1985). An additional study of 1, 233 students and 58 instructors it was found that 75.9% of instructors and 43.3% of students suffered injuries due to aerobics (Richie, 1985). The purpose of a majority of the studies investigating aerobic injuries has been identifying the prevalence and existence of the problem, but not the cause. In a survey by Davis and Bahamonde (2000) sixty- four aerobic instructors were asked about the possible causes of injury. Fifty-percent reported that shoes were the primary or secondary cause of injury and the primary reason for discarding the shoes was the lack of shock absorption. The purpose of the study was to evaluate the actual wear placed on the shock absorption characteristics of aerobic shoes worn by aerobic instructors using material testing procedures.

METHODS: A sample of aerobic instructors (n=11) was recruited from Indianapolis, IN. The sample consists of female instructors who gave informed consent. The instructors were chosen based average weight (65 $\pm$ 3.5 kg), age(33 $\pm$ 7 years) , and height (129 $\pm$ 5 cm) data gathered in a previously conducted survey (Davis and Bahamonde, 2000). Most instructors taught a combination of high impact, low impact and step aerobics. The subjects were each given a free pair of shoes randomly assigned to them at no cost. The shoes selected were two popular brand name shoes (based on shoe sales - 50$ to $60 price) designed for aerobics, one of the shoes was especially design for women. The shoes were collected after 3 months of use (approximately 30-40 hours), as determined by a previously conducted survey. After completion of the baseline testing and proper labeling the shoes were distributed to the instructors. In addition to the footwear, subjects received a journal and were asked to use the shoes only for their aerobic classes. The journal was designed for the subject to enter their hours of use, the type of class they taught, and any comments they may have had.
Each pair of shoes was tested using a 1000 Hz AMTI force platform to record the forces transmitted during an impact. A standard drop-dart test was used to measure the force of impact. The shoe was placed over the force platform and a 0.80 kg dart was dropped from a height of 1.50 m, which exerted a force of approximately 2.5 BW on a control shoe. The drop dart was dropped at the heel and at the toe box. This was accomplished by positioning a piece of PVC pipe to guide the dart over the toe box area. The force transmitted through the shoe onto the force plate was recorded (see Figure 1). The magnitude of the force and the area

under the curve were used to determine the shock absorption of the shoe (Bahamonde and Malone, 1996). The shoes were tested at the heel and at the toe box with the insole and without the insole. We tested the shoes without the insole to determine the role of the insole on the shock absorption of the shoes. Three trials for each condition were performed and the average of the three trials were used in the analyses. Two-way ANOVA's were used to analyze the data at the p>.05.

Figure 1. Force Transmitted to Shoe



RESULTS AND DISCUSSION: Baseline data show statistical differences between the types of shoes and place of impact (see Table 1). Shoe A was statistically different from shoe B for the maximum force with insole (MFIN) (p=.003) and for place of impact (p<.001). The maximum force without insole (MFNIN) showed no significant difference between shoes but significant differences between places of impact (p<.001). The average impulse generated with the insole (AVIIN) shows no significant difference between shoes or place of impact. The average impulse generated without insole (AVININ) had significant differences between places of impact (p=.02).

Table 1 - Shock Absorbing Properties Before Wear (n = 11)

SHOE	IMPACT	MFIN (N)	MFNIN (N)	AVIIN (N·ms)	AVININ (N·ms)
A	**Heel**	**1379.7**	**1529.3**	**6.62**	**6.61**
A	**Toe**	**2439.2**	**2726.7**	**6.48**	**6.25**
B	**Heel**	**1818.2**	**2015.5**	**6.79**	**6.29**
B	**Toe**	**2528.5**	**2621.5**	**6.66**	**6.15**

Table 2 shows the results of the testing after 3 months of use (30-40 hours). Only shoe B showed statistical significant differences between baseline values (Table 1) and the values after 3 months of use (Table 2.) There were significant differences in MFIN and MFNIN ($p<.05$).

Table 2 - Shock Absorption Properties After 3 Month of Use (n = 11)

SHOE	IMPACT	MFIN (N)	MFNIN (N)	AVIIN (N·ms)	AVININ (N·ms)
A	**Heel**	**1463.7**	**1668.3**	**6.80**	**6.85**
A	**Toe**	**2487.0**	**2939.4**	**6.43**	**6.28**
B	**Heel**	**2015.6**	**2269.4**	**7.08**	**7.17**
B	**Toe**	**2674.7**	**2956.8**	**6.86**	**6.28**

The results of the study indicated that there is considerable difference in the shock absorption properties of aerobics shoes. Shoe B, which is considered a shoe designed for aerobics and women, performed poorly compared to Shoe A, allowing 76% and 39 % more force transmitted to the heel and toe respectively. The insole of the shoe accounted for 9% reduction in the maximum force before the shoes were used. After wear, the insole accounted for about 14% of the force reduction, which indicates that the mid-sole was able to absorb less force. After 3 month of use, Shoe A maintained similar shock absorption properties but Shoe B show a statistically significant increases of 6-13% at the heel and toe. Increases in impulse ranged from 2-14%. The vertical ground reaction during aerobics can range from 2-3BW for high impact to 1 ½ BW for low impact (Ricard & Veatch, 1990; Du Toit & Smith, 1998). Considering that the majority of the impact is placed on the forefoot, aerobics shoes should be designed with better padding in the toe box. Aerobics instructors keep their shoes between 3-6 months (Davis and Bahamonde, 2000) and, depending on the instructors, the number of hours of use could reach 200 hrs. The combination of excessive use, poor shock absorption on the toe region, and the type of shoe could lead to an increase in injuries to the lower extremity of aerobic instructors.

CONCLUSION: The shock absorption properties of the aerobic shoes seem to be related to the brand name. Considering that Shoe A had much better properties than shoe B and it was able to maintain these properties after 3 months of use. Unlike running shoes that the heel take most of the impact, in aerobics the impact occurs at the ball of the foot (toe box), which is the area of the shoe that has the least amount of support. The insole also plays an important role in absorbing the impact. It is recommended that aerobics instructors select their shoes by taking the insole and shock absorbing properties of the mid-sole into consideration and not just brand name. When purchasing shoes, instructors should consider the thickness and stiffness of both the insole and midsole and should simulate common aerobic steps to feel the shock absorption properties of the shoes. Material testing of shoes in a controlled laboratory setting has certain limitations. Such controlled testing cannot simulate actual conditions but rather utilizes comparable situations to gain insight into complex situations.

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