A COMPARISON OF THE CUSHIONING EFFECT OF THREE TOP RATED RUNNING SHOES AND A SHOE USING A NEW SPRING TECHNOLOGY

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The purpose of this study was to compare the cushioning effect of three top rated running shoes and a new spring shoe technology. Shoes were mechanically dropped onto an AMTI force platform. The average in peak forces and the time to peak force were calculated to compare cushioning effect over multiple trials. The Nike and the Spira were found to be significantly better in both cushioning variables than the Adidas and Asics, but not significantly different from each other.

KEY WORDS: peak force, time to peak force, shoe cushioning.

INTRODUCTION: Shoe construction plays a critical role in the comfort as well as function of a shoe. Additionally, the construction of a shoe can impact the forces on the tissues and joints of the lower body and therefore influence injury. For example, ground reaction forces during running can reach two to three times body weight (De Wit, De Clercq & Aerts, 2000; Liu & Nigg, 2000). From the standpoint of injury prevention, a shoe, which can reduce the impact forces during landing, is desirable (Nigg and Sesser, 1992). Shoes that have been designed to improve cushioning have been found to significantly reduce compression and shear strain on the tibia of walkers (Milgrom, Finestone, Ekenman, Simkin & Nyska, 2001). There has been an increased focus on understanding the etiology of running injuries. Increased attention given to footwear may positively impact the reduction of running injuries. A better understanding of lower extremity biomechanics as well as shoe construction is necessary to find the right shoe (Senatore, 1996).

The amount of shoe cushioning has been demonstrated to have positive effects on various populations. A group of 92 diabetics with the risk of developing ulceration or re-ulceration of the feet were provided with specialized cushioned footwear (Bush & Chantelau 2003). When compared with common footwear, the protective footwear had a positive effect on the prevention of sores and blisters. Only fifteen percent of the patients fitted with the softer specialized shoes suffered from ulceration or re-ulceration during the 42-month study. Sixty percent of patients that wore normal footwear suffered continued foot ulceration over the same period of time.

The significance of shoe softness during prolonged work in an upright position was found to have an effect on the biomechanical and comfort measurements related to the lower extremities and the low back (Hansen, Winkel & Jorgensen, 1998). The study found that wearing soft shoes rather than hard clogs reduced ground reaction forces on the heel by approximately half. EMG-signs of paravertebral muscle fatigue were significantly larger during the use of clogs as compared to the soft shoes during 8 hours of standing during work.

Shoe cushioning can also impact athletes. A previous study tested ten males running at a speed of 4.5 m?s-1 over a force plate. The researchers tested a hard shoe and a softer shoe that had 50% more cushioning as measured by an instrumented impact tester. The softer shoe resulted in a significantly longer time to vertical force impact peak reading of 26.6 ms as compared to the harder shoe with a reading of 22.5 ms (Clarke, Frederick & Cooper, 1983).

Traditionally, running shoe soles have been constructed from materials such as ethyl vinyl acetate (EVA) foams. New technology includes features such as rubber shock absorbers, air cells or gel pockets imbedded in the heel of popular running shoes. These new features have been highly promoted as improvements in the construction of traditional type running shoes. The claims of improved shoe construction have generated reliability studies. For example, a new technology that featured soft lateral-wedge insoles reduced varus torque in patients with osteoarthritis (Kerrigan, et al. 2002).

Spira developed a new technology in shoe construction, which incorporated a unique spring, called the WaveSpringTM into a shoe (Spirafootwear.com, 2003). The technology is relatively new as the first shoes were introduced in El Paso, TX, USA in January 2002. The shoes are

being marketed to athletes as well as individuals who work on their feet all day. To date, only anecdotal evidence exists supporting the claims made by the new company. The purpose of this study was to compare the shoe cushioning effect of three top rated running shoes and a fourth shoe that used the new spring technology.

METHODS: A mechanical shoe-drop model (SDM) equipped with an aluminum shank and a prosthetic foot was manufactured to resemble the human lower leg (Figure 1). Three running shoes and one spring shoe were tested using the SDM. The running shoes used in the study were top rated Nike Air Pegasus, Adidas Ride, Asics Gel-Nimbus III (Consumer Reports, 2003) and a non-rated Spira ShoeSpring SSR-1(Note: Since the completion of the study, ShoeSpringTM has changed its name to Spira). Previous studies have estimated cushioning effect by measuring peak force and time to reach peak force (McCaw, Heil and Hamil, 2000). Shoes exhibiting lower peak force and higher time to peak force were deemed to have a higher cushioning effect. The SDM was raised to a height of 7.62 cm between the lowest part of the prosthetic foot and the surface of the force platform. A height calibration device was used before each drop trial to ensure accurate shoe to floor distance. Each shoe drop was initiated by pressing a latch that released a clamp mechanism. Once the clamp was opened the simulated lower extremity and selected shoe dropped on to the plate. Each of the four shoes was dropped ten times onto an AMTI Force platform. The average in peak forces and the time to peak force were calculated to compare cushioning effect. The data were analyzed using an ANOVA with Tukey post hoc comparisons and an alpha of .05.

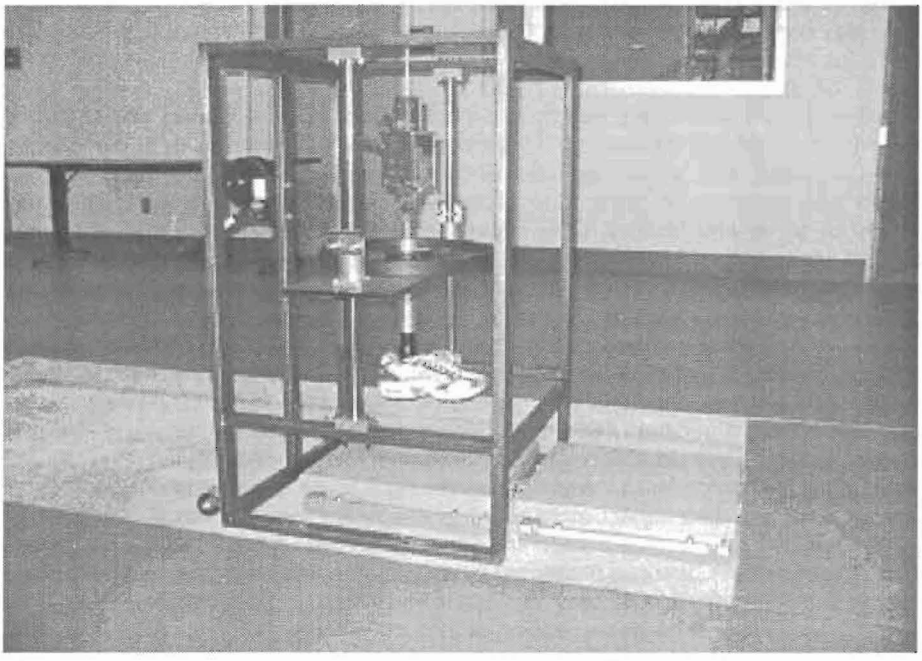

Figure 1: Shoe-Drop Model (SDM) with aluminum shank, prosthetic foot and shoe

RESULTS: The average peak force values are reported in Table 1. Significant differences were found among the means ($F = 11.354$, $p = .000$). Tukey post hoc analysis revealed the Nike and Spira exhibited significantly less force than the Adidas and Asics.

Table 1 Means (SD) for Force (N).

Nike (A)	Spira (B)	Adidas (C)	Asics (D)
1592.04 (227.8)	1687.72 (216.6)	1915.99 (25.9)^{A,B}	2089.44 (279.5)^{A,B}

Note. Superscripts (A, B) denote significant difference at $p < .05$ in the Tukey post hoc comparison (i.e. a variable with a superscript means the variable is significantly different from the subsequent variables superscripted)

The means for time to peak are reported in Table 2. Significant differences were found among the means ($F = 48.134$, $p = .000$). Post hoc analysis revealed time to peak was significantly greater for the Nike and Spira than for the Adidas and Asics. Additionally, the Adidas time to peak was significantly greater than the Asics.

Table 2 Mean (SD) for Time to Peak (ms).

Nike (A)	Spira (B)	Adidas (C)	Asics (D)
2.28 (0.18)	2.35 (0.15)	1.95 (0.11)$^{(A,B)}$	1.70 (0.11)$^{(A,B,C)}$

Note. Superscripts (A, B, C) denote significant difference at $p < .05$ in the Tukey post hoc comparison (i.e. a variable with a superscript means the variable is significantly different from the subsequent variables superscripted).

DISCUSSION: The purpose of this study was to compare the shoe cushioning effect of three top rated running shoes and a fourth shoe that used a new spring technology. The cushioning of shoes has been shown to have an impact on different populations. Different consumers, including diabetics, workers who have to stand and athletes, have benefited from research done on the cushioning properties of shoes (Bush & Chantelau, 2003; Hansen, Winkel & Jorgensen, 1998; Clarke, Frederick & Cooper, 1983). The new spring technology used in Spira and the soft construction of the Nike shoe resulted in significantly better cushioning effect than the Adidas or the Asics, as measured by peak forces and time to peak. Additionally, the Adidas time to peak was significantly greater than the Asics indicating superior cushioning for the Adidas. The continued research of impact forces conducted on human subjects may assist the practitioner in prescribing a quality shoe for various populations. With multiple styles and technologies to choose from in footwear, the practitioner may be able to promote healthier choices for the consumer.

CONCLUSION: Based on the results of the current study, the researchers would recommend the Spira and the Nike over the Adidas or Asics for consumers interested in cushioning. The need for further research on shoe cushioning construction and its effect on specific joint impact forces is warranted. Calculation methods such as inverse dynamics have allowed researchers to examine moments and forces at specific joints of the body (Vaughn, Davis & O'Connor, 1999). Impact forces that are dissipated by improved shoe cushioning at specific sites such as the ankle, knee and hip joints require human testing and should further be studied. Continued research can produce a potential consumer health benefit

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