

Topic: **The foot in motion: the dichotomy of shoe motion**

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January 2006

Synopsis

The paper will provide current research data that investigates the relationship of movement patterns between rearfoot and shoe motion. Footwear in sport is regarded as a medium to provide comfort, enhance efficiency of movement, have a prophylactic role and assist in rehabilitation. These assumptions are based on a close association of motion between two independent variables, the shoe and the foot. The results of the data will question the current methods that examine the foot in motion and will quantify the effect of footwear on foot motion. The objective will be to provide a clearer understanding of the three-dimensional motion patterns that simultaneously occur between the rearfoot and shoe.

Introduction

An important concept of the relationship between the athletic shoe and foot function should be the closeness of association of movement between the foot and the shoe.

Hypothetical dilemma:

Given that the shoe is a powerful manipulator of human performance what is the evidence that there is close correlation of movement between the shoe and the foot?

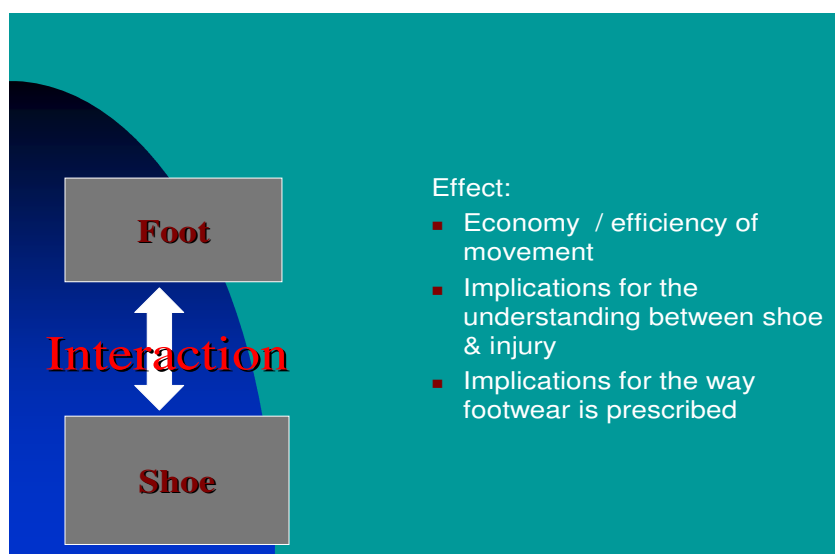
Hypothetical answer:

Currently, the clinician considers that footwear and motion cohesiveness occur because shoe shape has been pre-determined by foot shape and size in the construction principles of the shoe and that other variables can be minimized by a thorough foot and

lower limb biomechanical work up. The clinician comfortable with the empirical data that a patient will fall into a specific category of shoe; cushioned, stability, motion control, straight lasted, semi curved lasted and so on; will determined a shoe model by a range of testing procedures including foot morphology and mechanics based upon arch height, presenting pathology and what is the extent of weight bearing pronation and supination factors. Once the kinematics of the foot is established a shoe list is offered, and the closeness of fit ensures that the foot does not move within the shoe.

The role of footwear

A fundamental feature of footwear is to offer the foot protection from the environment. In its more contemporary role the shoe has undergone technological advances over the past thirty years with claims from major sporting footwear companies that it improves performance and offers protection from injury [1].



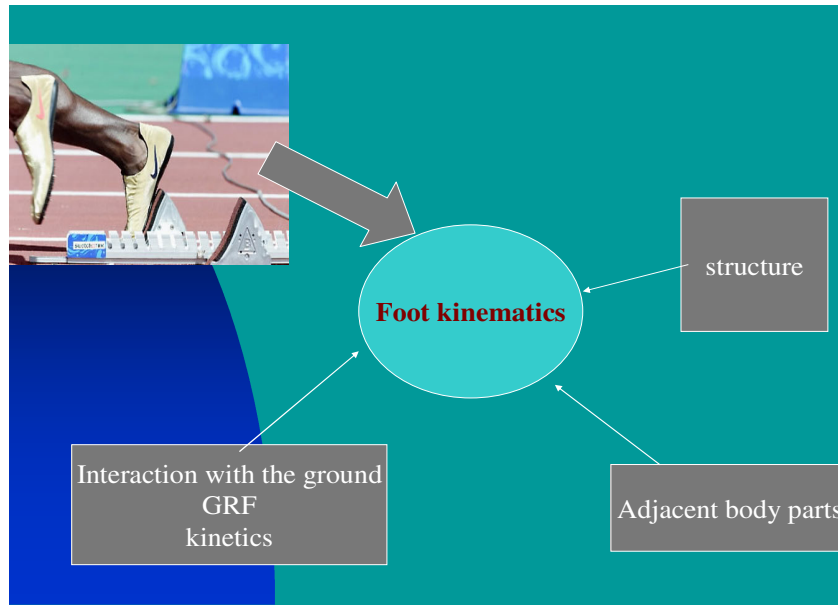
The primary role of footwear is: (1) to protect the foot; (2) to contribute to foot stability and comfort; (3) to provide shock attenuation; (4) to provide traction and thus enable

smooth transition from one step to the next; (5) to accommodate the anatomical alignment of the foot, allowing the foot to continually change from a mobile adaptor that conforms to ground variances to being a rigid lever to propel the foot into the next phase of the gait cycle.

In doing so the shoe satisfies the biomechanical criteria of foot function that has been offered by the pedal biomechanists [5,13] and assists in treating, accommodating foot deformities as well as having a prophylactic role in the prevention of sporting injuries [2,7,4].

Description of the problem

The evolution of shoe design over the past three decades, particularly within the area of sport shoe construction has led to statements that footwear is considered a powerful tool that manipulates human performance. Further there have been spurious marketing claims regarding the ability of athletic shoes to improve performance, provide comfort, protect from injury, assist with the rehabilitation of musculoskeletal injury and to conform to the principles of foot biomechanics [1,2,6].



However, what has not been established is common ground between motion control and motion enhancement principles. The commonly assumed principles that the foot and the shoe function with a close association of movement, synchrony of movement and are well correlated require further investigation. These issues are canvassed by Frederick in Seggesser and Proffinger (1989) as the dilemma and dichotomy of shoe design, while Stacoff (1991) stated that the effect of foot and shoe interaction is not known. Others have proposed a potential detrimental effect that footwear may have upon the ideals of injury, comfort and performance. A review of the literature has revealed that very little research has been presented on the movement of the shoe and its simultaneous relationship to the movement of the foot, a claim substantiated by Nigg et al., (1993) who stated that relative movement between the rearfoot and the shoe occur during running.

The evaluation of foot function and its relationship to shoe construction should involve the interpretation of quantitative rearfoot and shoe data that: (a) assesses the efficacy of

foot and shoe motion in foot and lower leg gait studies, (b) examines the design features of footwear that contribute to foot stability, (c) contributes to performance and comfort and (d) investigates the dual role of footwear in the prevention of injury and the provision of rehabilitative qualities via motion control, performance and enhancement.

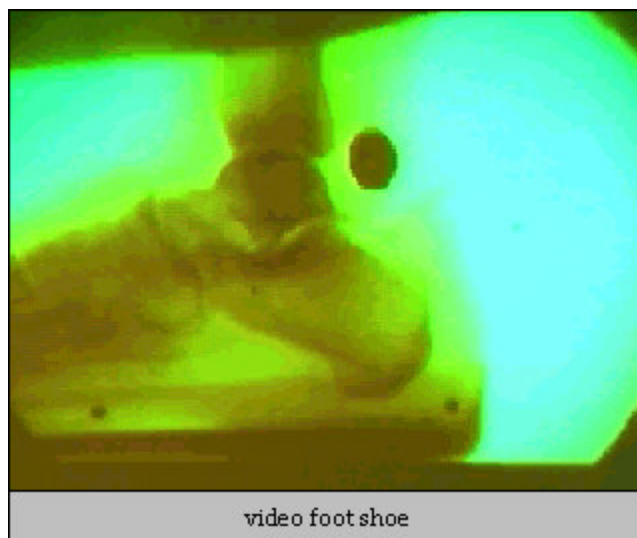
Evaluation of foot and shoe motion

The techniques that examine foot and shoe motion are divided into two categories. Firstly the role of midsole cushioning and the reduction of impact forces as a component of injury prevention. This type of analysis is thorough and well established. Secondly, the analyses of foot and shoe motion commonly involves modelling the rearfoot relative to the leg by the use of markers attached to the heel counter of shoes, the use of heel windows and in more recent times in-vivo rearfoot analysis by the use of bone pins. The use of shoe markers is widely referred to within the literature and is based upon the presumption that the information of shoe heel counter motion can be applied to actual rearfoot motion within the shoe. The information gleaned by these studies provided information on determining maximum rearfoot angle and the effect of shoe-sole construction. However studies by Reinschmidt (1992); Stacoff et al., (1992); Cornwall and McPoil (1995); McClay and Manal (1998) have indicated that heel markers do not provide an accurate description of rearfoot motion within the shoe. Furthermore it was considered by Nigg et al., (1986); Segesser and Pforringer (1989) and Stacoff et al. (1991) that there could be large movement between the foot and the shoe, although scientific investigation concerning this is still limited.

The use of heel windows as a method of determining in-shoe rearfoot provides a more direct measure of calcaneal motion. The limitation of this technique is considered to

destabilise the heel counter of the shoe [14]. Additionally, the size of the heel windows will affect heel movement within the shoe [10], a claim supported by McClay and Manal (1998) who deemed that heel windows may compromise the stability of the shoe counter and influence true calcaneal motion.

In recent times the use of intra cortical bone pins has had the advantage of negating the effects of soft tissue and skin movement in the analysis of lower limb and foot function [12, 10,16]. This method provides a direct comparison between shoe and foot motion with minimal affect to shoe counter stability. However, the use of bone pins is an invasive procedure, is not a widespread technique due to ethical considerations and by its nature can be applied only to small numbers of subjects.



Outcomes & Conclusion

The non-invasive studies provide qualitative data on rearfoot position by interpreting the movements of the heel counter of the shoe. The use of heel windows provides information on the rearfoot within the shoe at the expense of destabilising the shoe

thereby over-estimating the amount of foot motion relative to the shoe. Many of the studies provide frontal plane inversion-eversion results but no information about the two other angles of motion. The use of bone markers has the advantage of negating the effect of the errors introduced using surface markers and indicates that there is a significant difference between the motions of the foot and the shoe

Currently there is a paucity of data available on the relationship between foot motion and shoe mechanics. The following conclusions include that the use of heel counter markers are not representative of rearfoot motion, that there are significant differences for range of motion between the shoe and the foot and that shoes have a large effect upon an individual's foot motion without a general systematic effect, as the interaction of the shoe and the foot will vary from individual to individual. The speculation is therefore that there is not a close association between the foot and the shoe for movement, which will have implications for movement efficiency, injury prevention and performance enhancement ideals of athletic footwear.

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