BIOMECHANICALLY DRIVEN DEVELOPMENTS IN SPORTS SHOE TECHNOLOGY: THE EXAMPLE OF TUNED AIR

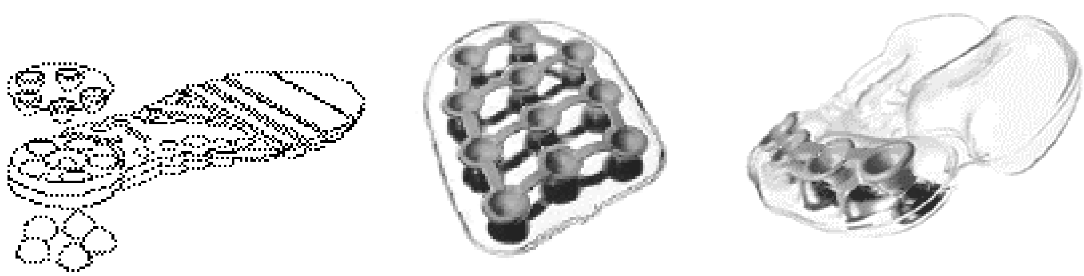
Martyn Shorten
Biomechanica LLC, Portland, Oregon, USA

INTRODUCTION

Frequently, forces other than biomechanical science are the major drivers of product innovation in the athletic footwear industry. Innovations in materials science, new manufacturing processes, socio-economic forces and lifestyle trends are more common determinants of new product directions. Although biomechanics can play an important role in the development of new products, its influence is often unclear. The purpose of this presentation is to highlight the role of biomechanics in the sports shoe product development process, using NIKE's Tuned AIR technology as an example.

CONCEPT DEVELOPMENT

From a biomechanical point of view, it is possible to specify cushioning properties or spring stiffnesses for different parts of a shoe sole. These specifications are difficult to implement with conventional cushioning materials, however. Typical foams are variable and cannot be made to precise specifications. The homogeneity of foam makes it difficult to implement different cushioning stiffnesses in one sole. Breakdown of foam materials with use can also lead to significant changes in cushioning properties over the life of the shoe.



A B C

Figure 1: Original concept (A) and NIKE Tuned AIR implementations in (B) basketball and (C) running shoes.

Tuned AIR is based on the „SkySole®" concept (Skaja and Shorten, 1996); a thermoformed shoe sole incorporating moulded cushioning elements. This technology was conceived as a solution to some of the limitations of conventional foam cushioning. The thermoformed shell (Figure 1A) replaces the foam midsole and acts as a carrier for hemispherical or hemiellipsoidal spring elements. The hemispherical spring shape, which provides a smooth displacement profile while minimizing material stresses, was developed using finite element models (Figure 2). The force-displacement properties of individual springs can be manipulated („tuned") by using different materials, or by changing the wall thickness and geometry of the elements (Figure 3).

Specific applications of biomechanical information during concept development included the identification of the mechanical problem, the determination of the load distributions and loading rates that the sole would be required to accommodate and the establishment of target stiffness distributions. Conventional biomechanical methods were also used in the functional testing of prototypes.

PRODUCT DEVELOPMENT

NIKE's Tuned AIR technology was introduced in October 1998. Like most advanced Research and Development projects in the footwear industry, the path from conception to product was not a linear one. The original concept was adapted to existing systems and manufacturing processes by combining SkySole® cushioning elements with NIKE AIR® technology. The first products used hemispherical springs to distribute cushioning stiffness in basketball and training shoes (Figure 1 B) and as stabilizing elements in running shoes (Figure 1 C). More than 60 individuals can rightly claim to have made a significant contribution to the creation of Tuned AIR products. These include specialists in materials, design, product development, patents, manufacturing and marketing as well as biomechanics.

DISCUSSION

Of the thousands of new athletic footwear products introduced each year, few (if any) are driven by biomechanical principles or biomechanists alone. This is more a reflection of the overall complexity of the product development process than of the importance of the biomechanist's role. Indeed, many new athletic footwear products embody some degree of biomechanical knowledge.

New products do not require the discovery of new biomechanical principles to be successful. More frequently, the successful incorporation of biomechanical principles into products is the result of long-term collaboration between biomechanists, designers, product developers and marketers rather than of specific biomechanical innovations.

REFERENCES

Skaja, J.J. and Shorten, M.R. (1996) Shoe sole component and shoe sole construction method. US Patent # 5,572,804

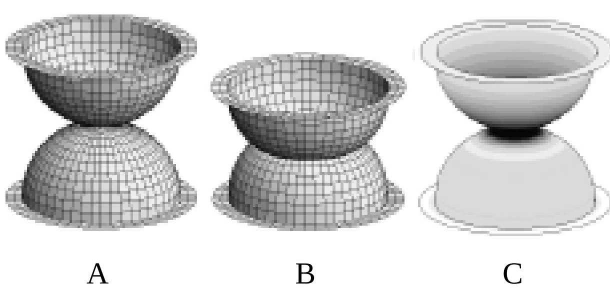


Figure 2: A. Hemispherical spring.
B. Deformation under normal load.
C. Stress distribution.

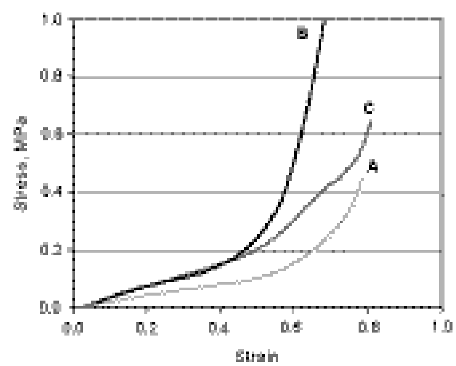


Figure 3:
A & B. Hemispherical springs with different wall thicknesses.
C. Hemiellipsoidal spring of same wall thickness as B.