FOOTWEAR BIOMECHANICS : WHAT DOES THE FUTURE HOLD?

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INTRODUCTION

Research is a process for exploring the unknown and, by definition, the outcomes of research are unpredictable. Consequently, any effort to predict the future of any scientific effort is destined to fail. While it cannot be presaged, the future path of footwear biomechanics research can be directed; provided that a consensus of researchers and other interest holders can agree on a direction.

This presentation highlights some of the issues the footwear biomechanics community must confront in order to develop as an academic discipline and to remain relevant to the designers, manufacturers and users of footwear. It represents one person's viewpoint based on narrow experience in the research and development of athletic footwear. It does not represent a consensus, and may be completely wrong; but if other voices join the discussion it will have served it's purpose.

UNANSWERED QUESTIONS

Twenty years ago, the footwear biomechanics community was asking fundamental questions about the links between footwear properties, human performance, health and injury.

In two decades, little progress has been made towards answering many of these questions. Compelling evidence of performance enhancement is sparse. While footwear is believed to play a role in the incidence and prevention of common athletic injuries, the etiology of injury and the mechanisms underlying footwear interventions are frequently unknown. "Adaptations" continue to be used to explain the non-appearance of expected effects, but their biological basis remains undocumented.

During the same timeframe, less fundamental questions have recurred. Are running shoes with harder or softer soles better? How can "energy return" be maximized? How do footwear properties influence the subjective perception of a product? Some such questions are not well defined and others can appear to focus on defining solutions without first clearly defining the problems.

UNSHIFTED PARADIGMS

When athletic footwear biomechanics entered the biomechanics mainstream thirty years ago, it inherited a body of knowledge from the podiatric, orthopedic and coaching communities. Based largely on the experience of practitioners rather than the results of controlled experiments, the inherited paradigms fueled much of the athletic shoe innovation that accompanied the running boom of the 1980's. Many of these paradigms persist. For example, the "stability paradigm" teaches that excessive pronation causes excessive internal tibial rotation and increases the risk of "runner's knee". A corollary of the stability paradigm says that runners with flat, flexible feet pronate more and need shoes that control pronation while those with high-arched, rigid feet do not pronate enough and need more cushioned shoes. Injury surveys (e.g. Clement *et al*, 1981) show that runners with malalignments of the lower extremities and/or hyperpronation have a higher risk of overuse injuries and clinicians find that controlling excessive pronation relieves symptoms. However, the paradigm is frequently contradicted by experimental results. For example, arch height and flexibility are not highly correlated in the general population. The coupling of subtalar pronation and internal tibial rotation is not absolute (Hinterman *et al*, 1994). Individuals with *pes planus* have less coupling than those with *pes cavus* (Nigg *et al*, 1999). Controlling pronation does not necessarily change lower extremity motion (Stacoff *et al*, 2000) or the loads on the knee joint. Runner's self-assessment of themselves as "pronators" is associated with arch height, but not

with lower extremity kinematics (Stefanyshyn *et al*, 2003), suggesting that they have been taught the paradigm.

Perhaps the most compelling reason for discarding the classical stability paradigm is the observation that the incidence of runner's knee and other overuse injuries has changed little in a quarter century, despite the wide availability of products with pronation control features. Other paradigms related to impact attenuation, traction and other footwear performance characteristics have similarly been questioned and are overdue for critical review.

CONSTRAINTS

To resolve old questions and develop new paradigms, the research community must identify constraints in the infrastructure, culture and process of research, then seek ways of lifting them. Some examples:

- The athletic, clinical and workplace footwear domains have distinct bodies of knowledge and there is little interaction among researchers in different fields. Also, a large portion of the research output is proprietary and accessible only to small groups of researchers. These divisions not only slow the pace of progress but also limit the effectiveness of peer-review.
- The availability of funding for basic (longer term) research is limited.
- There are no peer-reviewed journals with an emphasis on footwear biomechanics and only one regular scientific meeting (this one!) that focuses on the topic.
- Experiments are rarely repeated or independently validated in other laboratories – a necessary step for ensuring that observed effects are reproducible and for confirming conclusions.
- Few researchers have the resources to focus on a small set of related questions and investigate them over the course of a series of experiments, each more refined than the last. Sometimes, the outcome of an experiment is a hypothesis that is never tested.
- Relationships between academia and industry are sometimes strained, limiting communication and productivity.

BACK TO THE FUTURE

The existence of barriers to progress should not be cause for pessimism. On the contrary, my examples are all symptomatic of a young and highly applied research field that is experiencing a period of rapid development. The number of researchers and the volume of research work is growing rapidly. The supporting infrastructure and a culture of scientific excellence are also developing, but more sedately.

The future will be bright if we pay attention to developing scientific rigor, to addressing relevant questions and to effectively communicating the science to practitioners and end users. Rigor will come with the development of more focused avenues for publication, more vigorous peer review, and a culture that insists on independently reproducing important research results. The questions will come naturally with a focus on the needs of end users. If the research questions are relevant, there will be resources to support the research and opportunities to communicate its outcomes to an attentive audience.

Ultimately, the future offers an unrestricted but difficult choice. What do we want it to be?

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