**Optimizing Running Economy Through Footwear: A New Theoretical Framework**

This article examines a paper published in the *Journal of Applied Biomechanics*. You can find the paper here. Before delving into the framework, it’s helpful to first outline the key concepts of running economy, the spring-mass model, and advanced footwear technologies.

**Understanding Running Economy**

Running economy (RE) is a fundamental concept in distance running and refers to the oxygen cost required to maintain a constant running speed. The lower the oxygen consumption at a given pace, the better the RE, potentially allowing distance runners to sustain higher speeds for longer durations. RE is influenced by various factors, including biomechanics and external conditions such as footwear and running surfaces. Given its importance in endurance sports, optimizing RE has become a key focus in footwear development.

**The Spring-Mass Model of Running**

The spring-mass model is a widely used biomechanical approach to understanding human running mechanics. The model conceptualizes the body as a mass supported by the legs which behave in a spring-like way by compressing and rebounding with each step. Using this approach, economical running relies on optimizing the elastic properties of the legs to minimize energy expenditure. Footwear can theoretically influence the spring-mass system by altering the stiffness, energy return, ground contact time and other characteristics of the whole system. High-performance running shoes with advanced technologies potentially enhance RE by altering the behaviour of spring-mass characteristics of the system.

**Advanced Shoe Technologies**

Advances in footwear technology over the last 8 years have revolutionized the running industry by significantly improving RE and performance. Modern performance shoes incorporate high-energy-return midsoles made from advanced foams, which provide superior cushioning and responsiveness while remaining lightweight. The inclusion of carbon fiber plates in these midsoles appears to enhance shoe stiffness and reduces work at the foot and ankle joints. Additionally, rocker designs in modern midsoles may facilitate smoother transitions through the gait cycle, potentially minimizing energy loss. These innovations seemingly work synergistically to improve RE.

**A New Approach to Footwear Selection**

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Traditional approaches to evaluating the impact of footwear on RE have primarily considered group-level effects, averaging results across runners, and attributing the average effect to footwear properties such as a thicker or stiffer midsole or greater energy return. However, research shows that individual responses to different footwear technologies vary substantially. To account for the systematic effect of advanced footwear technology and the individual variability, in this paper we propose a theoretical framework that differentiates the **direct** and **biomechanically mediated** effects of footwear on RE (figure 1).

Direct effects: Defined in the paper as “the impact of a change in the mechanical properties of footwear on RE while key biomechanical variables remain constant.” In essence, direct effects refer to changes in the spring-mass characteristics of the runner’s system and RE without altering foot and ankle biomechanics in a systematic way. For example, midsole energy return may directly influence the spring-mass system, and these mechanical effects are relatively consistent across runners.

Biomechanically mediated effects: Defined as “the observed change in RE when holding footwear constant while altering relevant ankle and foot characteristics to match those influenced by different footwear.” In other words, these effects occur when footwear changes impact ankle and foot biomechanics, which in turn alter the runner’s spring-mass characteristics and RE.

This framework highlights the importance of personalizing footwear choices based on optimizing an individual's biomechanically mediated response, allowing for a more precise understanding of how different runners may react to specific footwear technologies.

**Interdependence: A key to understanding footwear optimization?**

The concept of interdependence is central to the framework. Interdependence is the concept that many natural processes do not have easily discernible boundaries and are therefore difficult to isolate from each other. In this paradigm, the effect of footwear properties and the effect of an individual’s biomechanics are not isolated factors but are dynamically constituted. For example, the impact of a highly resilient midsole on RE is not merely a function of its energy return as measured in benchtop tests. Instead, the actual effect dynamically integrates with the runner’s leg spring mechanics. Recognizing and understanding the limits of this interplay enables a more tailored approach to footwear selection. Instead of recommending the same high-performance shoe to all runners, manufacturers and athletes would be able to assess how specific footwear technologies interact with an individual’s biomechanics to optimize RE.

**Potential Benefits of This Framework**

1. **Personalized Footwear Selection:** A greater understanding of the biomechanically mediated effects would allow runners to choose shoes that optimises RE and performance based on their physical and biomechanical characteristics.
2. **Enhanced Shoe Development:** A greater understanding of the direct and mediated effects would allow manufacturers to design footwear technologies that not only offer greater mechanical advantages but also offer optimisation for runners with different biomechanical patterns.
3. **Scientific Advancements:** Researchers can develop better testing methodologies to quantify and separate these effects, improving our understanding of footwear biomechanics.
4. **Regulations:** An understanding of these effects may reinforce current regulations of competitive distance running shoes.

**Conclusion**

The individualization of footwear for optimizing running economy represents an exciting evolution in sports science. By distinguishing between the direct and biomechanically mediated effects of footwear, this framework may provide a roadmap for footwear manufacturers, researchers and distance runners to understand the effects of footwear on RE and performance. As future studies refine these principles, runners may be able to look forward to more personalized and effective footwear options tailored to their specific needs.