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Progress in running footwear science to match shoe features to the runner's skill level

A mixed-methods approach and collaboration between Innsbruck and Calgary

Within the footwear biomechanics community, the topic of running shoes is a particular focus due to the ever-growing popularity of recreational running in our society. In fact, running is among the most popular types of physical activity in Canada and Austria. While the popularity of running has tremendous benefits for public health through reducing the risk for non-communicable disease (e.g. obesity, cancer, diabetes, heart disease, etc.), running can cause musculoskeletal injury. Depending on the definition of injury, at least 20% and up to 80% of runners report running-related musculoskeletal complaints at any given time. Some of those complaints are thought to be preventable through appropriate running footwear.

Traditionally, the relationship between running footwear and running-related injuries has been understood within the framework of two biomechanical paradigms: Shoes that 1) reduce "impact forces" when the runners' foot strikes the ground, and 2) reduce "foot pronation" (i.e. the inward rolling of the foot during ground contact) are protective of running-related injuries. Nigg, Mohr, and Nigg (2019) outlined, however, that there is little evidence to support those paradigms and that instead the footwear biomechanics community should rethink the approach for running injury prevention through footwear. A more promising approach may be to try and match footwear properties to the specific needs of functional groups of runners, e.g. groups based on similar running experience and skill level.

The goal of the presented collection of research projects was to guide and facilitate the future scientific approach for matching running shoe features to the specific needs of novice, recreational, and high-caliber runners. **This was a collaboration between the Department of Sport Science at the University of Innsbruck [Maurice Mohr] and the Human Performance Laboratory at the University of Calgary, Canada [Benno Nigg and Sandro Nigg]** with an international reputation for their expertise in footwear biomechanics. Through a mixed-methods research design, we achieved the following research outcomes:

1) A systematic review of 68 articles summarized the existing evidence regarding the function of 20 common running footwear features with respect to leg and foot movement, running-related injuries, perceived comfort, and running performance in runners of different skill levels. A key finding was that – contrary to common belief – novice runners can benefit from running shoes incorporating thinner midsoles (i.e. the cushioning material between the outer sole and the insole) and a lower heel-to-toe drop (i.e. a "flatter" shoe) to reduce their risk of running-related injury *[Article 1]*

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2) A Delphi study with over twenty running footwear experts led to consensus on how to match important footwear features (breathability, bending/torsional stiffness, heel-to-toe drop, heel crash-pad) to the skill level of a runner. Interestingly, there was no consensus on the most studied footwear feature, i.e. rearfoot cushioning, which highlights the need for additional high-quality experimental studies on the function of this feature. *[Article 2]*
3) A biomechanical study was conducted to establish methodological guidelines for valid experiments to study the function of specific running footwear features. The key finding was that runners adapt their running style to the experimental protocol. Therefore, the guideline for future studies in this research area is that a familiarization/warm-up period of at least 7 minutes or 600 strides of running is required before any experimental conditions should be tested. *[Article 3]*

These outcomes provide a framework for runners, clinicians, footwear manufacturers, and footwear scientists, in which outdated paradigms are replaced by evidence-based findings and expert consensus on how running footwear can help reduce running-related injury and how footwear features with unknown function are best studied experimentally.

<u>Based on this work, we can formulate the following guidelines to runners:</u>

- Thicker running shoe midsoles and a more cushioned heel region do not automatically prevent running injuries. Consider switching back and forth between two different running shoe models for different training sessions, one model that is more cushioned and one model with a thinner sole and a lower heel-to-toe-drop.
- In most cases, running injuries occur as a result of training errors not as a result of footwear. Make sure to increase your running volume slowly.

<u>Based on this work, we can formulate the following guidelines to footwear scientists:</u>

- When testing the influence of different running footwear features on the running style (e.g. foot or leg movement), make sure to include a warm-up period of at least 7 minutes of 600 strides of running for each participant so that their running style has sufficient time to adapt to the experimental protocol.
- More high-quality experimental studies are needed to understand the influence of heel cushioning on footwear comfort, injury risk, and running performance.