Shoe cushioning, body mass and running biomechanics as risk factors for running injury

A randomised controlled trial

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Introduction

Running is one of the most popular forms of physical activity. From a public health perspective, the promotion of leisure-time running might be a powerful strategy to combat the pandemic of physical inactivity worldwide. Although regular running activity has a massive beneficial impact on health, it also generates a relatively high number of injuries, especially at the lower limb. Repetitive loading of the musculoskeletal system is suggested to be involved in the underlying mechanism of the majority of running-related injuries. Accordingly, heavier runners are assumed to be at a higher risk of injury. The cushioning system of modern running shoes is expected to protect runners against high impact forces, and therefore, injury. However, the role of shoe cushioning in injury prevention remains unclear. Therefore, we designed an innovative and ambitious research project to investigate:

1. The effect of shoe cushioning on injury risk
2. The effect of body mass on injury risk
3. The role of body mass on the association between shoe cushioning and injury risk
4. The influence of shoe cushioning on running biomechanics
5. The potential biomechanical injury risk factors
6. The influence of bodyweight on running biomechanics

The present report will address the first four objectives.

Methods

This double-blinded randomized controlled trial included 874 healthy leisure-time runners. They randomly received one of two shoe prototypes that only differed in their cushioning properties (global stiffness: 61±3 and 95±6 N/mm in the Soft and Hard versions, respectively). Participants were tested at baseline on an instrumented treadmill (equipped with force plates) at their preferred running speed. They were then followed over six months during which they were asked to continue their usual running practice and to report all their running activity and injury (any physical complaint reducing/interrupting running activity for at least seven days) in the TIPPS system (Training and Injury Prevention Platform for Sport).



Figure 1 : Study shoes.

Results

Participants

The analysis included 848 leisure-time runners who reported 24 170 running sessions in the TIPPS system. A total of 220 014 km were covered with the study shoes, which were used for 97 % of the sessions. The median body mass was 78.2 and 62.8 kg in males and females, respectively. The average self-selected running speed on the treadmill was 10 km/h. More than 275 000 steps were analysed (325 steps per participant on average).

Injuries

Over the 6-month period, 128 participants (15 %) reported at least one running-related injury in the TIPPS system. The overall incidence was 5.7 injuries per 1000 hours of running. The most affected areas were the ankles (26 %), knees (22 %) and lower legs (18 %). Tendinitis (48 %) and muscle damage (19 %) were the most common types of pathologies. It is also interesting to note that more than 85 % of injuries were progressive, and about 25 % of them led to a reduction/interruption of running activities for more than 4 weeks.

Shoe cushioning and injury risk

The runners who had received the Hard shoes had a higher injury risk (Hazard Ratio - HR = 1.52; 95 % Confidence interval – CI = 1.07 to 2.16).

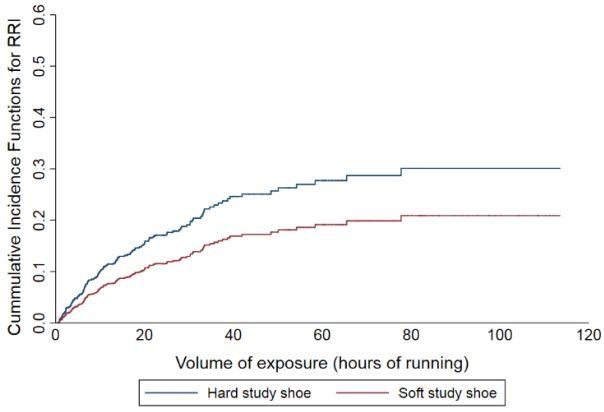


Figure 2 : Cumulative incidence functions for running-related injury (RRI).

Body mass and injury risk

Body mass was not associated with injury risk. No significant association between body mass index (kg/m^2) and injury risk or between the proportion of fat mass and injury risk were found either.

Role of body mass on association between shoe cushioning and injury risk

After stratification of the cohort according to body mass, the results showed that lighter runners had a higher injury risk in Hard shoes (HR = 1.80; 95 % CI = 1.09 to 2.98) while heavier runners did not (HR = 1.23; 95 % CI = 0.75 to 2.03).

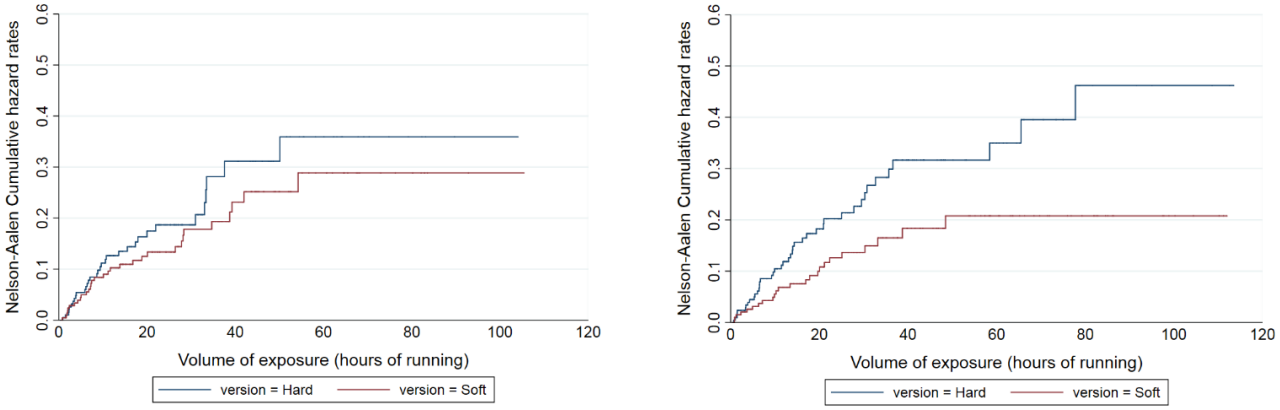


Figure 3 : Cumulative incidence function for running-related injury in heavier (Left) and lighter runners (Right). Cut-off value = 78.2 and 62.8 kg in males and females, respectively.

Shoe cushioning and impact forces

No difference was observed between the study groups among the spatiotemporal variables such as step cadence (164±9 and 164±10 steps/minute in the Soft and Hard shoe groups, respectively), step length (1.00±0.14 and 1.01±0.15 meter) and contact time (291±36 and 291±38 milliseconds).

The main variables computed from the vertical ground reaction force (GRF) signal, which was recorded during the running test in the laboratory, are presented on Figure 4. Vertical impact peak force and Vertical instantaneous loading rate are commonly considered as injury risk factors.

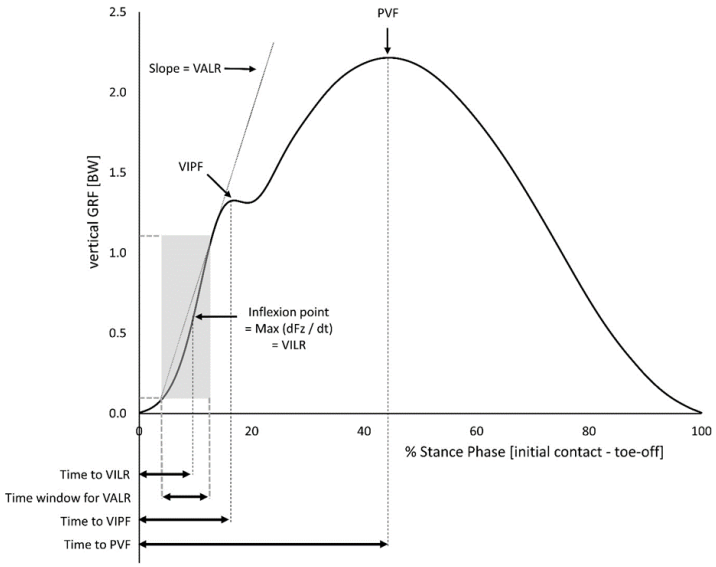


Figure 4 : Schematic illustration of outcome variables derived from the vertical ground reaction force (GRF) curve. VIPF: Vertical Impact Peak Force; PVF: Peak Vertical Force; VILR: Vertical Instantaneous Loading Rate; VALR: Vertical average loading rate; Fz: Vertical force signal; BW: Body weight. This illustration is not representative for steps without VIPF.

A significantly higher vertical impact peak force (95 % CI = 0.07 to 0.13 BW; 6.9 %) was observed in the Soft shoe group compared to the Hard shoe group (Figure 5 A), but no difference was observed for vertical instantaneous loading rate (Figure 5 B). The difference may be small, but could result in a clinically meaningful difference when considering the phenomenon over several thousand steps taken during a training session.

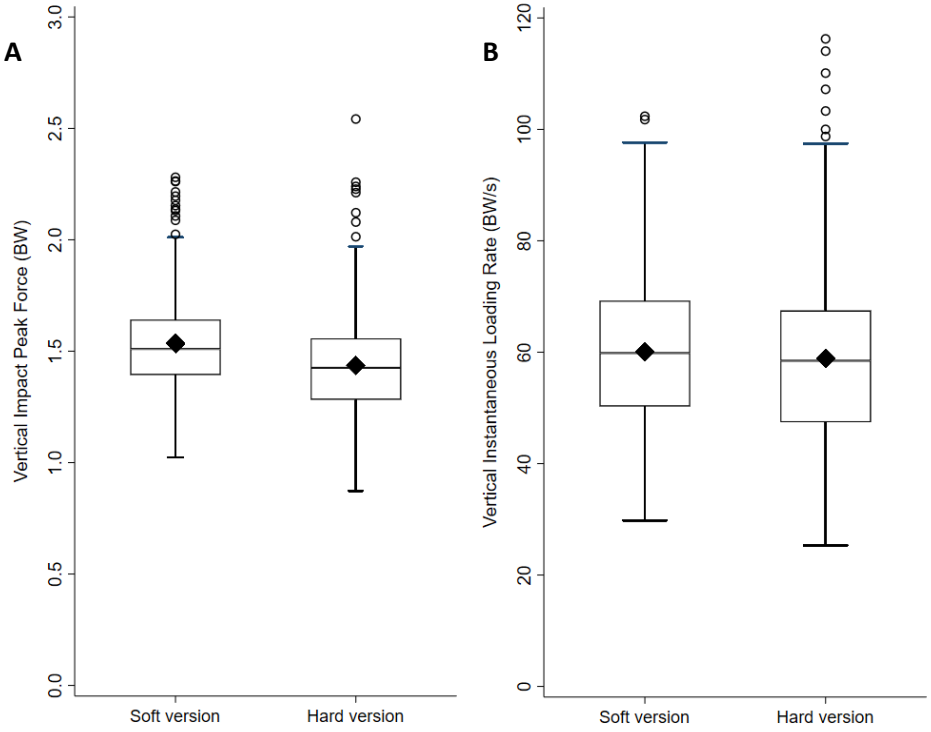


*Figure 5 : Box plots for Vertical Impact Peak Force (BW, p<0.001, Panel A) and Vertical Instantaneous Loading Rate (BW/s, p=0.071, Panel B) in the two experimental groups (n=428 and 420 for the Soft and Hard shoe group, respectively). The lower and upper box boundaries indicate the 25th and 75th percentiles, respectively, the middle line inside the box represents the median, and the filled diamond is the mean. Whiskers below and above the boxes represent the [25th percentile – 1.5 * interquartile range (IQR)] and [75th percentile + 1.5 * IQR], respectively. Empty circles are data falling outside of the whiskers.*

Conclusions

1. **Shoe cushioning influenced injury risk in leisure-time runners overall: runners who received the shoes with greater cushioning had a lower injury risk.**
2. **Neither body mass nor the proportion of fat mass were identified as risk factors for running-related injury.**
3. **Light runners are at a higher risk of injury when using shoes with less cushioning, while no shoe effect was observed in heavy runners, in contrast with popular belief. Thus, light runners should prefer shoes with greater cushioning, for heavier runners this is not so important.**
4. **Vertical impact peak force was higher in the group of runners who received the Soft shoe version compared to those with the Hard shoe version. No difference between shoe types was observed for loading rate. As injury risk was lower in the group with the Soft shoe version, the beneficial effect of greater cushioning cannot be explained by a decrease in impact force and loading rate.**

Further analyses of the dataset collected during the study are ongoing (or foreseen), and additional publications are expected in the coming years.

This research project was performed in collaboration with Decathlon SportsLab.

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Decathlon SportsLab, research center focused on the athlete's body, supports the development of Decathlon products. Research engineers investigate sensorial, physiological and physical phenomenon in athletes during their practice, in laboratories as well as on the field. Their scientific expertise focusses on athlete's protection and performance improvement.

References

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