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## Archives of Physical Medicine and Rehabilitation

Volume 78, Issue 5, May 1997, Pages 463-467

Article

# Balance and vertical impact in sports: Role of shoe sole materials

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[https://doi.org/10.1016/S0003-9993\(97\)90157-X](https://doi.org/10.1016/S0003-9993(97)90157-X)

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### Abstract

**Objective:** Athletic shoes and mats are support surface interfaces composed of relatively soft compressible materials designed to protect against injuries occurring in sports through force of vertical impact. Impact remains high with their use because humans land harder with them. We hypothesize that this hard-landing strategy is an attempt by the user to improve stability, by compressing the material to a less destabilizing thinner-stiff variety. We tested this hypothesis by comparing impact and balance on materials consisting of ethyl-vinyl acetate (EVA) foams of varying stiffness, identical to that found in soles of athletic footwear.

**Design:** Randomized-order, crossover trial, controlled comparison; blinded.

**Setting:** Volunteers were selected from the general community.

**Participants:** A random sample of 12 healthy men from the general population (mean age 30 years, SD  $\hat{\pm}$  6). Additional selection criteria were absence of disabilities influencing ability to walk, run, and balance, and no history of frequent falls.

**Methods:** Impact testing and stability measures were performed on the same test day. Ground reaction forces were measured for ten barefoot footfalls. The protocol required stepping forward from perch to surface 4.5cm below. Stability testing was performed with one-legged standing consisting of placing left foot on top of right for 30sec, barefoot, eyes open, and gaze straight, with arms to side. Subjects confronted four surface conditions presented in random order: a bare rigid platform, and the platform covered with one of three 2.5-cm-thick materials.

**Results:** Steady state vertical impact was a negative function of interface stiffness, with the softest interface producing the greatest vertical impact, and the stiffest interface the least vertical impact. Vertical impact and stability measures were also negatively related, with the strongest correlation obtained with the softest interface ( $r = \hat{\cdot}.87, p < .001$ ). No relation between these variables was obtained for the rigid surface.

**Conclusion:** Balance and vertical impact are closely related. This supports the hypothesis that landing hard on soft surfaces is an attempt to transform the interface into a form associated with improved stability. According to these findings, currently available sports shoes and mats are too soft and thick, and should be redesigned to protect the persons using them.



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for shoe last design, multiplication of two vectors (vector) shifts the  
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