FOOTWEAR EFFECTS ON IMPACTS AND LOWER-LIMB MUSCLE RESPONSES DURING ACTIVE AND UNEXPECTED LANDINGS

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SUMMARY

The aim of this study was to investigate the effect of basketball shoes on the impact force and lower-limb muscle activities during landings. Twelve male basketball players were requested to wear two types of shoes to achieve five trials of double-leg drop jumps and unexpected drop landings. Ground reaction forces, accelerations of the shoe heel-counter, and myoelectric signals of five lower-limb muscles were collected simultaneously. During active landing, the intervention of basketball shoe did not significantly change the characteristics of impact force and muscle activity patterns. However, under the condition of related muscles were not being activated properly, the basketball shoe reduced the impacts and decreased the muscle post-activation. This potential effect of footwear may further be developed in preventing sports injury and enhancing metabolic efficiency during landings or in fatigue.

INTRODUCTION

The concept of "shoe cushioning" has been suggested to reduce impact loading during athletic activities for 30 years [1, 2]. Recently, a series of paradigms, considering the repetitive impact force as an input signal, have been provided [3]. It has been proposed that changes in muscle activity during landing in locomotion might be responsible for minimizing the magnitude of the soft-tissue vibrations that are initiated at landing phase [4]. However, to date, few rigorous scientific studies have been conducted to investigate the role of footwear during more strenuous landing tasks based on the interaction between the impact force and muscle adjustments (tuning), which may further be utilized in the functional design of the footwear.

Therefore, the aim of this study was to explore the effect of basketball shoes on (1) the impact force and (b) pre-/post-landing muscle activities during active landings (drop jump) and unexpected drop landings.

METHODS

Twelve male basketball players were recruited for this experiment. They wore two types of shoes [basketball cushioning shoe (BS) vs. control shoe (CS) without cushioning insoles] to achieve five trials of double-leg landing by using a custom-made platform. Two landing styles [drop jump (DJ) and unexpected drop landing (UDL)] and three drop heights (30 cm, 45 cm, and 60 cm) were adopted in the test.

Ground reaction forces (GRF, Kistler, 1200Hz), accelerations of the shoe heel counter, and myoelectric signals for the tibialis anterior (TA), lateral gastrocnemius (LG), rectus femoris (RF), vastus lateralis (VL) and biceps femoris (BF) muscles (Biovision, 1200Hz) were collected simultaneously.

The main variables discussed in this study for the impact force were peak vertical GRF (F_{Zmax}) and the peak acceleration of the shoe heel counter (a_{heel}); while for muscle activity was the root mean square (RMS) of EMG, which was performed in the interval 50 ms prior to contact to the time of first contact (pre-activated) and contact to 50 ms after initial contact (post-activation). A $2 \times 2 \times 3$ (shoe × landing style × height) repeated measures analysis of variance (ANOVA) was used to determine the effects of the shoes and the drop heights on impact performance and muscle activities. Tukey post hoc tests were used to determine individual significant differences. The significant level was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Impacts: during the contact phase of DJ, the patterns of the vertical GRF-time curves, as well as the heel acceleration-time curves, in BS and CS conditions were similar. Contrarily, for the UDL, the effect of basketball shoes on the impact forces was a significant decrease in vertical GRF and heel-counter accelerations (Figure 1). Specifically, The ANOVA results showed no main effects of shoe type for the F_{Zmax} and a_{heel} during DJ at all heights. However, the post hoc comparisons showed that the F_{Zmax} and a_{heel} with basketball shoes was significantly lower than that of the control shoes across all three heights in the UDL task ($p < 0.05$) (Table 1).
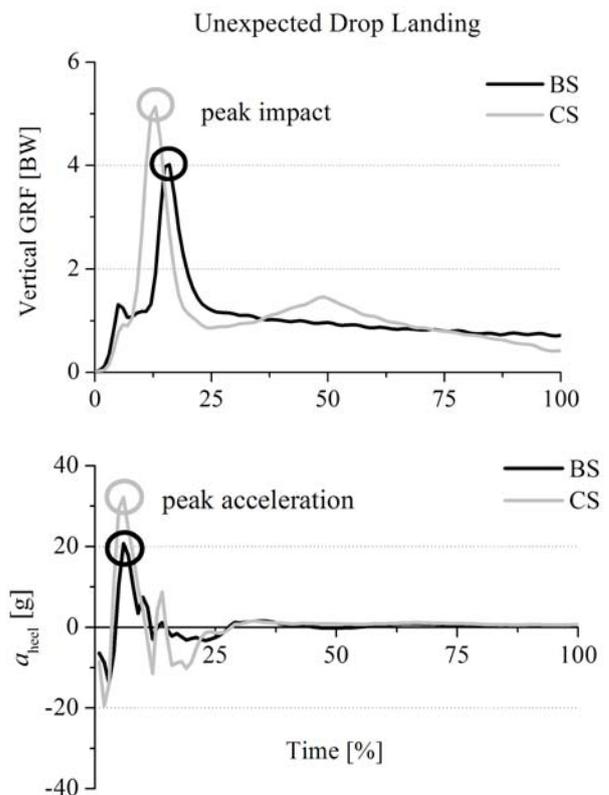

Figure 1: Representative vertical GRF-time and heel acceleration-time curves during landings from a 60 cm height in basketball shoe (BS) and control shoe (CS) conditions.

Muscle pre-activation (-50 ms): For the five muscles tested (TA, LG, RF, VL, and BF), there was no significant shoe effect on the normalized EMG amplitude both during DJ and UDL in all three drop heights. However, what interested us most was a significant decrease in the EMG intensity for the UDL compared to the DJ for the TA, LG, RF, and VL muscles ($p<0.05$).
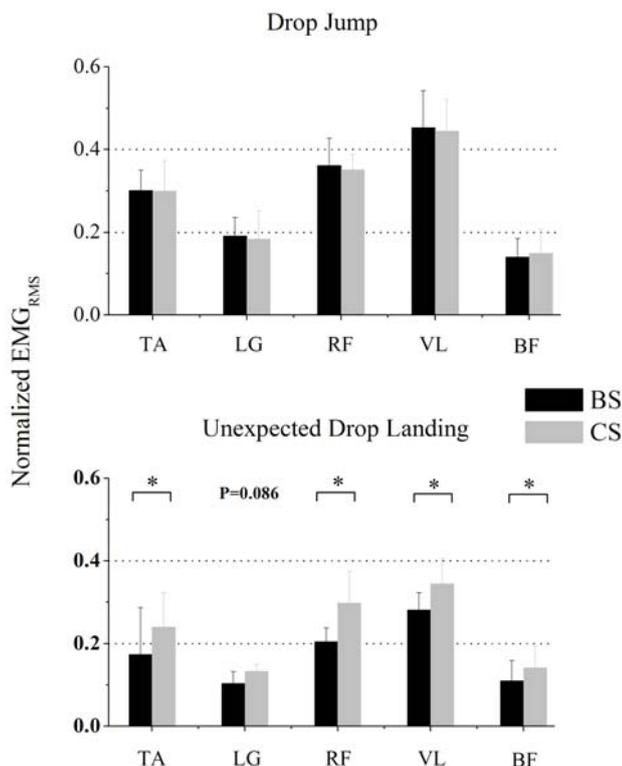
Muscle post-activation (+50 ms): For the DJ, no significant differences in the RMS of the EMG were observed for any of the tested muscles (Figure 2). However, during UDL, the EMG amplitude of TA, RF, VL, and BF showed a significant decrease for the basketball shoe compared to control shoe from 60 cm drop height except for the LG ($p = 0.086$) (Figure 2). Additionally, on average there was a decrease in the EMG post-activation for the UDL condition compared to DJ.

CONCLUSIONS

During active landing, the intervention of basketball shoe did not significantly change the characteristics of impact force as well as muscle activity patterns. This suggests that shoe intervention may have limited effects on reducing the impact as an input signal provided neuromuscular adjustments are occurred properly during active movements (e.g. drop jumps and running). However, under the condition of related muscles were not being activated properly, such as in unexpected drop landings, the basketball shoe reduced the magnitude of impact and decreased muscle post-activation. Potentially, this effect of footwear may further be developed in preventing sports injury and enhancing metabolic efficiency during landings or in fatigue.

Figure 2: Influence of basketball shoe on the normalized EMG for the five muscles during drop jump and unexpected drop landing from a height of 60 cm.

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Table 1: The effect of footwear on peak impact (Fz_{max}) and peak acceleration of the shoe heel counter (a_{heel}) during landings.

Variables	Height / Shoe Group	Drop Jump			Unexpected Drop Landing		
		30cm	45cm	60cm	30cm	45cm	60cm
Fz_{max} (BW)	BS	2.13±0.51	2.74±0.42	3.59±0.81	**3.29±0.47***	**3.56±0.80***	**4.06±0.71***
	CS	2.17±0.50	2.82±0.80	3.60±0.64	3.90±1.16	4.35±1.02	4.73±0.84
a_{heel} (g)	BS	21.9±4.2	26.9±8.4	29.4±7.2	**22.8±7.9***	**24.8±5.3***	**28.9±7.3***
	CS	24.0±7.6	27.8±8.5	32.7±7.4	28.8±5.7	32.5±9.5	35.8±7.9

Note: BS, basketball shoe; CS, control shoe. * Indicate significant differences between the shoes in same height with $p<0.05$.