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## The effect of basketball footwear on the vertical ground reaction force during the landing phase of drop jumps

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### THE EFFECT OF BASKETBALL FOOTWEAR ON THE VERTICAL GROUND REACTION FORCE DURING THE LANDING PHASE OF DROP JUMPS

KEY WORDS: Basketball, Vertical jump, Reaction force.

ABSTRACT: Even though the aetiology of overuse injuries is multifactorial, repetitive impacts and insufficient cushioning have been pointed out as the main causes of injury. These impacts are characterized at the vertical ground reaction force by 2 peaks. The first corresponds to the landing of the forefoot (F1) and the second (F2), associated to the production of injuries. Basketball footwear, due to its design and materials, might also help cushion the impact of the foot with the ground. Nevertheless, it has not been ascertained whether this footwear reduce the impact of the foot with the ground. The aim was to determine the effect of basketball footwear on the vertical ground reaction force during the landing phase of drop jumps. Thirteen students of the University of the B. Country (age =  $21.54 \pm 1.12$  yr; body mass =  $71.83 \pm 8.15$  kg; height =  $177 \pm 7$  cm) took part. They all were required to perform 3 drop landings (DL) from 30 cm (DL30) and 60 cm (DL60) high in 2 different conditions: with basketball footwear or with running footwear. Resting period between jumps was 60-90 s. We presented data from 30 cm,  $2.27 \pm 1.07$ , v ( $m \cdot s^{-1}$ ) with basketball footwear and  $2.49 \pm 1.23$  v ( $m \cdot s^{-1}$ ) with the alternative one. In F2, the analysis concluded that the parameter in both, 30 cm and 60 cm, presented differences between basketball and running sport shoes ( $6.20 \pm 1.93$  vs.  $5.72 \pm 1.79$  Bw;  $9.34 \pm 2.16$  vs.  $8.27 \pm 2.07$  Bw). The F2 values recorded with running shoes were lower than those recorded when wearing basketball footwear (DL30: 11.13% DL60: 11.46%). The fore and rear foot impacts and loading rate are higher when jumping from 60 cm under both conditions. The F2 was the only statistically distinctive parameter between shoe conditions from both heights with lower values for non-basketball footwear.

Even though the aetiology of overuse injuries is multifactorial (Rolf, 1995), repetitive impacts and insufficient cushioning have been pointed out as the main causes of injury production (Donohue, Buss, Oegema and Thompson, 1983; Ewers, Weaver, Sevensma and Haut, 2002; Radin et al., 1978; Radin, Paul and Rose, 1972; Wilk et al., 2006). During sport activities, these impacts occur mainly during the landing phase of a jump, leading to a stress on the musculoskeletal system (Bressel and Cronin, 2005; Pribut, 2010). These impacts are characterized at the vertical ground reaction force by two peaks. The first peak corresponds to the landing of the forefoot (F1) and the second peak (F2), associated to the production of injuries (Dufek and Bates, 1991; McNair, Prapavessis and Callender, 2000; Mizrahi, Versbitsky and Isakov, 1999), corresponds to the landing of the rearfoot (Bressel and Cronin, 2005; Mizrahi et al., 1999; Ozguven and Berme, 1988; Seegmiller and McCaw, 2003).

Taking into account that basketball players make an average of 44 jumps per match (Ben Abdelkrim, El Fazaa and El Ati,

2007) up to 70 cm high (McInnes, Carlson, Jones and McKenna, 1995) independently of their playing position (Ostojic, Mazic and Dikic, 2006), it is not a surprise that these athletes are very likely to injure their lower limb especially during competition (Boroswki et al. 2008). Basketball injuries are usually overuse injuries, such as stress fractures (Newman and Newberg, 2010), what explains that basketball players usually cannot relate their injuries to one incident but rather to a problem that is chronic (Henry, Lareau and Neigut, 1982). Therefore, the reduction of the magnitude of F2 to decrease the impact of the rear foot with the ground may help to reduce this injury rate. Another parameter that should be considered is the loading rate, which describes the relationship between the magnitude of the forces and the elapsed time from the first contact of the foot with the ground to the production of these forces (Woodard, James and Messier, 1999). High magnitudes of this parameter have been also related to the production of stress injuries (Radin, Yang, Riegger, Kish and O'Connor, 1991) and a reduction of its magnitude would also

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decrease the injury rate. Basketball specific footwear, due to its design and materials, might also help cushion the impact of the foot with the ground. Nevertheless, it has not been ascertained whether this footwear reduce the impact of the foot with the ground. The aim of our study is to determine the effect of basketball footwear on the vertical ground reaction force during the landing phase of drop jumps.

**Methods**

**Participants**

Thirteen physically active students of the University of the Basque Country (age = 21.54 ± 1.12 yr; body mass = 71.83 ± 8.15 kg; height = 177 ± 7 cm) took part in the study. They were selected from third course of the Sport Sciences Faculty in Vitoria, Spain. Inclusion criteria were to have a basketball playing experience of at least 5 years in competition and to be free of injuries at the time of the study. Subjects taking medications or with allergies were excluded from the study. All the subjects trained 4 to 5 days per week and had no history of musculoskeletal injuries. The study was conducted in accordance with the Declaration of Helsinki. Subjects were informed about the experimental procedures and produced informed written consent.

**Procediment**

The test session was scheduled at least 48 hours after any competition or physical training session to minimize the influence of previous activity. Subjects underwent a 10-min standardized warm-up consisting of 8 min of jogging followed by a series of dynamic movements (e.g. lunges and skipping). No static stretching was allowed since previous studies have demonstrated negative effects of stretching on various jump variables (Cornwell, Nelson and Sidaway, 2001).

They all were required to perform 3 drop landings (DL) from 30 cm (DL30) and 60 cm (DL60) high in two different footwear conditions: 1) with basketball footwear and 2) with running footwear. The resting period between jumps was 60-90 s (Cometti, Maffiuletti, Pousson, Chatard and Maffulli, 2001). All the subjects were familiarized with the DL technique. Subjects were asked to place their hands on their hips to eliminate the influence of the upper limb (Hara et al., 2008) and to drop down off the box landing on a force platform with both feet at the same time. Vertical ground reaction force data were collected at 500 Hz using a force platform (Kistler, Quattro Jump, Switzerland).

**Results**

Tables 1 and 2, show the descriptive results of the GRF under both shoe conditions and from both heights.

	Basketball footwear		Running footwear	
	Mean ± SD	95% CI	Mean ± SD	95% CI
F1 (BW)	2.27 ± 1.07	1.86 - 2.59	2.49 ± 1.23	2.05 - 2.93
F2 (BW)	6.20 ± 1.93*	5.51 - 6.88	5.72 ± 1.79	5.09 - 6.36
T1 (s)	.02 ± .01	.01 - .02	.02 ± .02	.01 - .02
T2 (s)/T2 (s)	.05 ± .02	.04 - 0.052	.05 ± .02	.04 - .05
LR1 (BW·s <sup>-1</sup> )	166.30 ± 88.03	135.86 - 197.51	198.83 ± 112.32	159.06 - 238.65
LR2 (BW·s <sup>-1</sup> )	93.20 ± 47.80	76.25 - 110.16	105.53 ± 94.48	77.05 - 144.04
TTS (s)	.50 ± .13	.46 - .55	.52 ± .14	.47 - .57

Note. \* : significant differences for p < .05 with the running footwear.

F1: Maximum magnitude of the vertical ground reaction force during the landing of the forefoot, F2: Maximum magnitude of the VGRF during the landing of the rear foot, T1: Time to the production of F1, T2: Time to the production of F2, LR1: loading rate of F1, LR2: loading rate of F2, TTS: time to stabilization.

Table 1: Ground reaction forces from 30 cm high.

	Basketball footwear		Running footwear	
	Mean ± SD	95% CI	Mean ± SD	95% CI
F1 (BW)	4.65 ± 2.19	3.87 - 5.43	4.18 ± 1.87	3.51 - 4.84
F2 (BW)	9.34 ± 2.16*	8.57 - 10.13	8.27 ± 2.07	7.53 - 9.09
T1 (s)/T1 (s)	.01 ± .01	.01 - .01	.01 ± .01	.01 - .01
T2 (s)	.03 ± .01	.03 - .04	.03 ± .01	.03 - .04
LR1 (BW·s <sup>-1</sup> )	166.30 ± 88.03	135.86 - 197.51	198.83 ± 112.32	159.06 - 238.65
LR2 (BW·s <sup>-1</sup> )	93.20 ± 47.80	76.25 - 110.16	105.53 ± 94.48	77.05 - 144.04
TTS (s)	.84 ± .50	.66 - 1.02	.70 ± .23	.62 - .78

Note. \* : significant differences for p < .05 with the running footwear.

F1: Maximum magnitude of the vertical ground reaction force during the landing of the forefoot, F2: Maximum magnitude of the VGRF during the landing of the rearfoot, T1: Time to the production of F1, T2: Time to the production of F2, LR1: loading rate of F1, LR2: loading rate of F2, TTS: time to stabilization.

Table 2: Ground reaction forces from 60 cm high.

## Discussion

To our knowledge, this is the first study that looks into the effect of the basketball specific footwear on the vertical component of the ground reaction forces. This phenomenon has already been studied (Baca, 1999) but not in basketball, although differences in footwear have been proved to have an influence on the GRF (Cavanagh, 1981). Our main findings show that: 1) forefoot and rear foot impacts and loading rate are higher when jumping from 60 cm under both shoe conditions; and 2) F2 was the only statistically distinctive parameter between shoe conditions from both heights with lower values for non-basketball footwear.

When talking about the GRF, F1 is the magnitude of the first peak after landing and its production time. Our results presented data from 30 cm,  $2.27 \pm 1.07$ , v ( $m \cdot s^{-1}$ ) with basketball footwear and  $2.49 \pm 1.23$  v ( $m \cdot s^{-1}$ ) with the alternative one, were very similar to the ones found in previous research (McNitt-Gray, 1993).

When regard to F2, the statistical analysis concluded that this parameter in both situations (30 cm and 60 cm, respectively), presented differences between basketball and running sport shoes ( $6.20 \pm 1.93$  vs.  $5.72 \pm 1.79$  Bw;  $9.34 \pm 2.16$  vs.  $8.27 \pm 2.07$  Bw), recent studies demonstrated that drop jumps from heights >40 cm, offered no advantages in terms of mechanical efficiency and stiffness (Peng, 2011), in the changing biomechanical properties, given that the lack of biomechanical efficiency and the potentially increased risk of injury.

The impacts of fore- and rearfoot and loading rate showed greater values when landing from 60 cm high, which is congruent with the results in previous studies (McNitt-Gray, 1993; Zhang, Bates and Dufek, 2000) where a direct correlation was described between the magnitude of the impacts and the height of the jumps.

The only difference between shoe types was found for F2 from any height. The F2 values recorded with running shoes were lower than those recorded when wearing basketball footwear (DL30: 11.13% DL60: 11.46%). This means that basketball boots had a lower cushioning effect, which is surprising at least being aware of the high impact level of the game itself and the expected capability of the specific footwear to reduce those repetitive and high impacts on the players' bodies. The rest of the variables of the vertical component of the GRF did not show differences between footwear conditions in any height. This absence can be interpreted as a flaw in our design because time to stabilization is measured in the vertical axis and not on the medial-lateral one where differences would be more likely to appear due to their high ankle cuff. The force platform available measured the vertical components only which are, by the way, the biggest magnitude of them all (Whittle, 2003).

In summary, the forefoot and rear foot impacts and loading rate are higher when jumping from 60 cm under both shoe conditions and the F2 was the only statistically distinctive parameter between shoe conditions from both heights with lower values for non-basketball footwear.

### EL EFECTO DE LAS BOTAS DE BALONCESTO EN LA FUERZA DE REACCION DURANTE EL ATERRIZAJE

**PALABRAS CLAVE:** Baloncesto, salto vertical, fuerza de reacción.

**RESUMEN:** Aunque la etiología de las lesiones por sobreuso es multifactorial, los impactos repetidos y la amortiguación insuficiente, han sido propuestos como dos de las principales causas de lesión. Los impactos son caracterizados por la fuerza de reacción vertical del suelo en dos picos. El primero de ellos, se corresponde con el aterrizaje de la parte delantera del pie (F1) y el segundo (F2), está más asociado a la producción de lesiones. El calzado de baloncesto, debido a su diseño y materiales, también podría ayudar a amortiguar el impacto del pie con la tierra. Sin embargo, no ha sido averiguado aún, si este calzado reduce dicho impacto. **Objetivo:** El objetivo de este estudio, fue determinar que el efecto del calzado de baloncesto sobre la fuerza de reacción de la tierra en la componente vertical durante el aterrizaje.

Treinta estudiantes de la Universidad del País Vasco (Edad =  $21.54 \pm 1.12$  años; masa corporal =  $71.83 \pm 8.15$  kg; Altura =  $177 \pm 7$  cm) tomaron parte en este estudio. Todos ellos, realizaron 3 aterrizajes, después de ejecutar un salto drop (DL) desde 30 cm (DL30) y desde 60 cm (DL60) de altura, en 2 condiciones diferentes: con calzado de baloncesto o con calzado de running. El periodo de descanso entre saltos fue de entre 60 a 90 seg. Se presentan datos desde 30 cm de altura,  $2.27 \pm 1.07$ , v ( $m \cdot s^{-1}$ ) con calzado de baloncesto y de  $2.49 \pm 1.23$  v ( $m \cdot s^{-1}$ ) con calzado de running. Respecto a F2, el análisis concluyó que en ambas alturas desde 30 cm y desde 60 cm, se presentaron diferencias entre las botas de baloncesto y el calzado de running ( $6.20 \pm 1.93$  vs.  $5.72 \pm 1.79$  Bw;  $9.34 \pm 2.16$  vs.  $8.27 \pm 2.07$  Bw). Los valores de F2 registrados con calzado de running fueron más bajos que los registrados con los de baloncesto (DL30: 11.13% DL60: 11.46%). Los impactos de la parte delantera y de reverso, son más altos cuando se ejecutan los saltos desde 60 cm con ambos calzados. El parámetro F2, fue el único estadísticamente distinto entre ambos calzados, desde ambas alturas de salto, con valores más bajos para el calzado de running.

### EFEITO DAS BOTAS DE BASQUETEBOL NA FORÇA DE REACÇÃO DURANTE OS APOIOS

**PALAVRAS-CHAVE:** Basquetebol. Salto vertical, Força de reacção.

**RESUMO:** Embora a etiologia das lesões por sobrecarga seja multifactorial, os impactos repetidos e o amortecimento insuficiente, têm sido propostos como duas das principais causas das lesões. Os impactos são caracterizados pela força de reacção vertical ao solo em dois picos. O primeiro, corresponde à aterragem com a parte dianteira do pé (F1) e o segundo (F2), está mais associado à ocorrência de lesões. O calçado de basquetebol, devido ao seu design e materiais, também poderia ajudar a amortecer o impacto do pé com o solo. No entanto, não se verificou ainda, se este calçado reduz o dito impacto. **Objetivo:** o objetivo deste estudo foi determinar o efeito do calçado de basquetebol na força de reacção no solo na componente vertical durante a aterragem. Trinta estudantes da Universidade do País Vasco (idade =  $21.54 \pm 1.12$  anos, massa corporal =  $71.83 \pm 8.15$  kg, altura =  $177 \pm 7$  cm) participaram neste estudo. Todos eles, realizaram três aterragens, após a execução de um salto drop (DL) desde 30 cm (DL30) e desde 60 cm (DL60) de altura, em duas situações diferentes: com calçado de basquetebol ou de corrida. O período de descanso entre saltos compreendeu-se entre os 60 e 90 seg. Os dados são apresentados a partir dos 30 cm de altura,  $2.27 \pm 1.07$ , v ( $m \cdot s^{-1}$ ), com calçado de basquetebol e de  $2.49 \pm 1.23$  v ( $m \cdot s^{-1}$ ) com calçado de corrida. Quanto a F2, a análise concluiu que, em ambas alturas de 30 cm e de 60 cm, havia diferenças entre o calçado de basquetebol e de corrida ( $6.20 \pm 1.93$  vs  $5.72 \pm 1.79$  BW;  $9.34 \pm 2.16$  vs  $8.27 \pm 2.07$  pc). Os valores de F2, registados com calçado de corrida foram mais baixos que os registados com o de basquetebol (DL30: DL60% 11,13: 11,46%). Os impactos da parte dianteira e de trás, são mais elevados durante a execução de saltos de 60 cm, com ambos os calzados. O parâmetro F2, foi o único estatisticamente diferente entre os dois calzados, em ambas as alturas de salto, com valores mais baixos para o calçado de corrida.

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