

# BIOMECHANICAL CHARACTERISTICS AND POWER GENERATION OF JUMPING ACTIVITIES IN CROSS-TRAINING SHOES

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## INTRODUCTION

Most footwear studies have concentrated on shoes used in running (De Cleq, et al., 1994; Nigg, 1995). There are few studies that have investigated footwear used in jumping (Stefanyshyn and Nigg, 2000). No specific studies have been found in the literature on the biomechanical characteristics of cross-training footwear. Cross-training footwear is designed to meet the needs of a variety of sports and sport training environment. Key features of training shoes include generating power for performance and attenuating impacts for injury prevention. These shoes should be able to withstand the rigors of different surface conditions. In addition, athletes must feel comfortable wearing these shoes in different activities and on different surfaces. Therefore, the purpose of this study was to examine biomechanical characteristics and power generation for jumping in different training shoes.

## METHODS

Ten healthy recreational male athletes (age:  $21.5 \pm 2.5$  yrs, body mass:  $83.3 \pm 9.0$  kg, height:  $1.80 \pm 0.1$  m) with no impairments to their lower extremities at the testing time participated in the study. A digital video camera (120 Hz) was used to obtain right sagittal kinematic data; a force platform (AMTI) for ground reaction forces (GRF) and two miniature accelerometers (Piezotronics, Inc. for forehead and the distal tibia accelerations (ACC) were sampled at 1200 Hz for 1.5 sec.

The subjects were instructed to perform five step-off landing trials and five maximum vertical jumping trials in each of the four training shoes (Shoe A – D, successful models from three leading companies) in eight test conditions (landing and jumping in 4 shoes). The landing height was determined individually based upon an amount of potential energy of a “mid-size” person (80 kg) landing from a 60 cm height. GRF data were normalized by multiplying respective jump height to control the effect of the different jump heights achieved by individuals. In addition, a pair of shoes from each model was also selected for material testing. Only jumping data were presented in this abstract.

At the end of the testing session, subjects filled out a survey form about their perception on cushion and comfort characteristics of the training footwear using 5-point Likert scale. A two-way 3 x 3 joint x height) repeated measures ANOVA and post-hoc comparisons were performed on selected kinematic variables; a one-way ANOVA was used to detect difference for jump height and selected GRF and ACC variables. The significance level was set at  $p < 0.05$ .

## RESULTS AND DISCUSSION

Kinematic differences among shoes were seen mainly in the ankle angular kinematics (Table 1). Shoes A and B demonstrated greater maximum dorsiflexion angles than

Shoe C. The plantarflexion angle at takeoff was greater for Shoe D than for Shoe A and C. The range of motion and maximum plantar flexion velocity was greater for Shoe C than for A and D.

For the lower extremity joints (not presented due to limited space), significant differences were observed between the knee and hip joint from the ankle joint kinematic variables. The hip joint had greater ROM and lesser peak plantarflexion angle than the knee and ankle joints.

**Table 1.** Selected ankle angular kinematic variables

Shoe	Amax	ATO	ROM	Vext
A	27.6 ±6	-31.9 ±6	59.4 ±5	-571 ±53
B	28.0 ±6	-32.6 ±6	60.2 ±5	-572 ±75
C	30.3 ±5 <sup>1,2</sup>	-31.6 ±6	61.9±5 <sup>1</sup>	-597 ±79 <sup>2</sup>
D	28.7 ±5	-30.1 ±6 <sup>1,3</sup>	58.9 ±5 <sup>3</sup>	-564 ±68 <sup>3</sup>

Note:

<sup>1</sup>: significantly different from Shoe A

<sup>2</sup>: significantly different from Shoe B

<sup>3</sup>: significantly different from Shoe C

Amax: maximum angle (degree)

ATO: takeoff angle (degree)

ROM: range of motion (degree)

Vext: maximum plantarflexion angular velocity (degree/s)

The GRF variables for jumping did not show significant changes across shoes except for differences of the minimum vertical GRF between A and D before the normalization was applied. However, significant differences were observed after applying the normalizing procedure to selected GRF variables (Table 2). Shoe C had significantly greater maximum vertical GRF than shoe A. Both shoe C and D had greater maximum power than shoe A.

The material testing results indicated that Shoe A and B had the smallest bending stiffness values (29.4 and 37.9 N/mm) compared to Shoe C and D (60.3 and 59.8 N/mm) obtained in a forefoot flexibility test. On the other hand, energy loss for Shoe A and B (41% and 43%) were greater than

Shoe C and D (33 and 35%). These results were consistent with the maximum power results and were in agreement with the findings of a previous study on forefoot stiffness (Stefanyshyn and Nigg, 2000). However, the perception scores (shown in a different abstract) suggested that Shoe C and D had harder perceived heel cushioning that may pose a potential threat to the body.

**Table 2.** Selected GRF variables

Shoe	FJmin	FJmax	PWmax
A	2.6±1.0	15.3±2.1	48.3±17.2
B	2.5±1.2	15.8±2.4	49.1±17.8
C	2.4±0.9	15.9±2.4	49.8±16.3 <sup>1</sup>
D	2.3±1.2 <sup>1</sup>	16.2±2.5 <sup>1</sup>	50.8±17.8 <sup>1</sup>

Note:

<sup>1</sup>: significantly different from Shoe A

<sup>2</sup>: significantly different from Shoe B

<sup>3</sup>: significantly different from Shoe C

FJmin: minimum vertical GRF (Nm/kg)

FJmax: maximum vertical GRF (Nm/kg)

PWmax: maximum power (Wm/kg)

## SUMMARY

The initial absences of significance in the jumping GRF data might be due to the jump heights were not the same for all subjects thus disguising the true differences among the shoes. After normalization Shoe D and C seemed to show better performance in the maximum power compared to Shoe A. Better performance may, however, come at a price, decreased comfort and cushioning.

## REFERENCES

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## ACKNOWLEDGEMENTS

This study was supported by a grant from Adidas America, Inc.