

A GRF COMPARISON BETWEEN LANDING FROM A COUNTERMOVEMENT JUMP AND LANDING FROM STEPPING OFF A BOX

Mostafa Afifi and Richard Hinrichs
Arizona State University, Tempe, AZ, USA
e-mail: mostafa.afifi@asu.edu

INTRODUCTION

Injuries occurring during landing from a jump are common in sports, particularly anterior cruciate ligament (ACL) injuries, which among college athletes are three times more common in females than males (Ireland, 1999). Thus, many studies have investigated the different biomechanical aspects of landing as well as compared differences between males and females.

A common practice among researchers is to have participants step off a box of a certain height to the ground. The purpose of this practice is to make sure participants are landing from the same height (Swartz et al, 2005). An assumption made that stepping off a box to the ground is similar to landing from a jump may be based on another assumption that touchdown velocity of the center of mass from a certain height is always the same.

If the two landings are found not to be the same, then this would cast a doubt on the validity of those studies that have used a box to mimic the landing from a vertical jump. Thus, the purpose of this study was to investigate if there are any biomechanical differences between landing from a countermovement jump and landing from stepping off a box.

METHODS

Eighteen active college students (9 males, 9 females) volunteered to participate in the study. Participants were excluded if they did not take part in sports that involved jumping

at least 2 to 3 times a week or if they had any orthopedic condition that would prevent them from jumping.

Each participant performed three maximal effort countermovement jumps (CMJs) on a force platform (1200 Hz, AMTI). Landing impulse was used to calculate an equivalent landing height (the fall height of the body center of mass prior to touchdown). A box was then set to an appropriate height to match the landing height from the countermovement jump. The participants then stepped off the box with their right foot. If the step off (SO) equivalent landing height did not match any of the CMJ landing heights, the box height as adjusted and procedure repeated until a matching height was reached.

A comparison was then made between the two trials of similar height. Although EMG and video data were collected as part of a larger study, only vertical ground reaction force (GRF) data are presented here.

A mixed design two-way ANOVA with repeated measures (condition \times gender) with condition as the within-subjects factor was used to analyze the time to peak GRF, peak GRF, and maximum loading rate (maximal slope in GRF curve between contact and peak force; Bus, 2002); see Figure 1.

RESULTS AND DISCUSSION

A significant main effect for condition was seen for time to peak GRF, $F(1,16) = 6.7$, $p < .05$, with no significant condition \times gender

interaction, $F(1,16) = .10$, $p = NS$. The SO landings produced significantly shorter times to peak GRF than did the CMJ landings (see Figure 1 and Table 1). Both peak GRF and maximal initial loading rate showed a significant jump type \times gender interaction. A test of simple effects showed the SO produced larger GRF and loading rates than the CMJ for males only, $F(1,16) = 17.65$, $p < .01$ and $F(1,16) = 12.95$, $p < .01$, respectively.

A shorter time to peak GRF suggests that individuals were less prepared for impact during the SO compared to the CMJ. The difference between the two landings was more pronounced in males. The gender difference may be related to the landing height as the males jumped significantly higher than the females (means of 0.31 m and 0.22 m, respectively), $F(1, 16) = 19.02$, $p < .001$.

Results from this study suggest true countermovement jumps should be used to study landings and not stepping off a box, as the two landing conditions produced significantly different force profiles.

Although not part of the original investigation, it was noticed that the equivalent landing heights when stepping off a box were on the average 0.10 m lower than the actual box height as participants tended to lower their foot, thus, lowering body center of mass prior to becoming airborne. This fact alone is troublesome for

all those prior studies that have assumed that the equivalent landing height and the box height are the same.

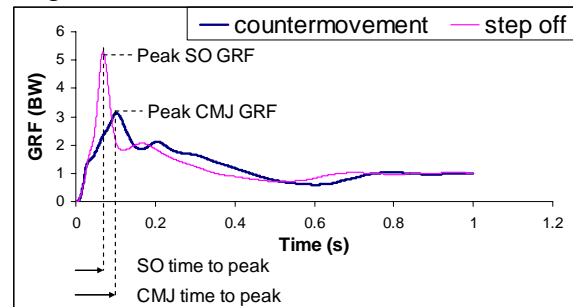


Figure 1. GRF in BW for both CMJ and SO landings for a typical male participant.

SUMMARY/CONCLUSIONS

A comparison was made between vertical GRF when landing from a countermovement jump and stepping off a box. Results suggest that these landings are not similar to each other. Compared to the CMJ, SO landings produced earlier peak GRF in both genders and greater peak GRF and loading rates only in males. Additional work needs to be done to see how these force differences are reflected in patterns of muscle activity and kinematics of landing.

REFERENCES

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Table 1. Mean values \pm SD for dependent variables for conditions and genders.

	Time to CMJ peak GRF (ms)	Time to SO peak GRF (ms)	CMJ peak GRF (BW)	SO peak GRF (BW)	CMJ max loading rate (BW·s ⁻¹)	SO max loading rate (BW·s ⁻¹)
Females	82.1 \pm 16	67.4 \pm 11.3	3.68 \pm 0.3	3.63 \pm 0.4	123 \pm 40	144 \pm 54
Males	83.0 \pm 14	63.8 \pm 5.7	4.45 \pm 0.8**	5.5 \pm 0.9**	186 \pm 97**	304 \pm 167**
All participants	82.5 \pm 14*	65.6 \pm 8.9*	4.09 \pm 0.7	4.6 \pm 1.2	158 \pm 77	224 \pm 145

* $p < .05$, significant main effect for condition

** $p < .05$, significant simple effect for condition