THE EFFECTS OF STEPPING OFF VS. HOPPING OFF A BOX ON CALCULATED DROP HEIGHTS IN TWO-LEGGED LANDINGS

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INTRODUCTION

When studying the mechanics of landing, the common practice is to have study participants step off or hop off a box onto the ground below. The box is intended to control for the height of the jump (Swartz et al., 2005). Thus, the step off or hop off studies assume that dropping in this case will be similar to landing from an actual countermovement jump from the ground. Recently we have reported the difference in mechanics of landing from a counter-movement jump and stepping off a box (Afifi and Hinrichs, 2006). Although both landings are different, stepping of a box may still be used when investigating other tasks such as falling if the drop height is consistent. However, in our study we noticed that calculated drop heights were approximately 10 cm less than the actual box height putting in question the validity of many studies that assumed drop heights were the same as box heights.

The purpose of the study was to investigate the difference in calculated drop heights from stepping off and hoping off boxes of different heights.

METHODS

Twenty active college students (10 males, 10 females) volunteered to participate in the study. Participants were excluded if they had any orthopedic condition that would prevent them from jumping.

Subjects were asked to do a series of stepping off and hopping off drops to a force platform (1200 Hz, AMTI). The box heights were adjusted to range from 20 to 45 cm with 5 cm increments in a balanced order such that each subject performed step off (SO) and hop off (HO) drops three times at six different heights. Participants were given instructions and shown an example of how to perform each type of drop. Landing impulse was used to calculate an equivalent dropping height (the fall height from rest of the body center of mass prior to touchdown). All trials were videotaped for qualitative analysis purposes.

A series of single sample t-tests were used to examine if calculated drop heights were significantly different from actual box heights. A mixed design three-way ANOVA with repeated measures (drop type × box height × gender) with gender as the between subjects condition was used to analyze the difference in calculated center of mass (CM) drop heights.

RESULTS AND DISCUSSION

Both types of drops showed significantly lower calculated drop heights than the actual box height (Figure 1). The magnitude of height difference gradually increased as the box height increased (Table 1). Regardless of the landing type, participants lowered their CM prior to takeoff. This is in agreement with our earlier study (Afifi and Hinrichs, 2006) for the SO condition. This may not have been expected for the HO condition; however, pilot testing had shown that HO differs with subject standing position in relation to the box edge. In this study, participants stood with their toes past the edge of the box. A lower calculated drop height for the HO condition was confirmed by qualitatively observing limb positions at takeoff.

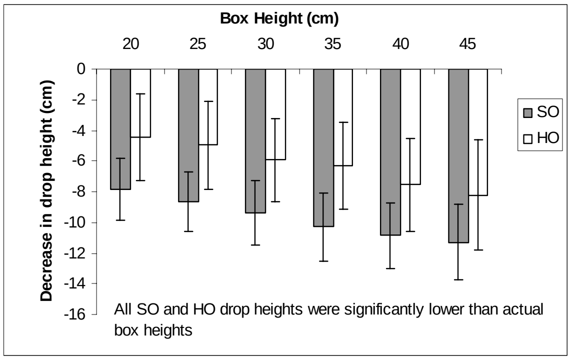

Figure 1. Mean CM height lost for each condition

The greater the difference between calculated drop height and actual box height as box height increased suggests that that subjects may have been subconsciously attempting to lower their centers of mass prior to takeoff, thus, reducing the risk of injury upon landing.

Table 1. The difference in height lost for each pair of box heights

BoxHt	20 cm	25 cm	30 cm	35 cm	40 cm	45 cm
20 cm		.79	1.51*	2.44*	2.99*	3.43*
25 cm	.55		.72	1.65*	2.20*	2.63*
30 cm	1.50*	.95*		.93	1.48*	1.92*
35 cm	1.91*	1.37*	.42		.55	.98*
40 cm	3.12*	2.57*	1.62*	1.20*		.43
45 cm	3.80*	3.25*	2.30*	1.88*	.68	

SO condition shown above the diagonal
HP condition shown below the diagonal
* Significant difference between pair of box heights, p<.05

A significant main effect for drop type was seen as SO heights were significantly lower than HO heights, $F(1,18) = 36.01$, $p<.001$,with no gender by drop type interaction, $F(1,18) = 3.7$, $p=.07$, no drop type by drop height interaction, $F(5, 90) = 1.33$, $p= .259$, and no gender by drop type by drop height interaction, $F(5, 90) = 2.13$, $p= .069$.

Participants in the SO condition decreased drop height more than the HO condition for all heights as one foot left the box first and they had control over when to leave the box with the other leg. This was not the case in the HO case where both feet left at once and there was no room for adjustment.

The decrease in drop height from actual box height ranged from 7.86 to 11.28 cm for SO and from 4.41 to 8.22 cm for HO. If precise control over the drop height is not needed then countermovement jumps should be studied as they relate to what happens in real-life jumping. However, when precise control of the drop height is needed then other methods to control height should be assessed. When studying falls, height may be controlled by having participants hold on to a bar and dropping. This methods has been used by some researchers, however, accuracy in controlling drop height remains to be tested.

SUMMARY/CONCLUSIONS

The difference in drop height when stepping off and hopping off a box were investigated. Both stepping off and hopping off lead to a decrease in drop height compared to the actual box height. The loss of height shows that the assumption that stepping or hopping off a box controls drop height is incorrect suggesting it would be best to study jump landing from actual jumps and fall landing from hanging on a bar and dropping. If SO or HO landings are to be used then the actual box height should be adjusted for each subject and each trial separately to ensure a relatively constant drop height and verified by impulse upon landing.

REFERENCES

Afifi, M. and Hinrichs, R.N. (2006). *Proceedings of ASB ’06.*
Swartz, E.E. et al. (2005). *Journal of Athletic Training*, *40*, 9-14.