EFFECTS OF JUMP TYPE ON GROUND REACTION FORCES DURING LANDING IN CHILDREN

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INTRODUCTION

Bone loss associated with osteoporosis increases the risk of fracture in older adults. However, osteoporosis might be delayed and the incidence of fractures among older adults reduced by increasing peak bone mass during growth. In particular, pre-adolescence appears to be more responsive to interventions for increasing bone mass than adulthood. Known stimuli for increasing bone mass are large forces applied at high loading rates, such as those during landing from a jump. Indeed, a 7-month program of drop landings from a 61cm height enhanced gains in bone mass in children [1]. In this study, we determined whether other types of jumping activities in children produced ground reaction forces similar to those of the previously-reported drop landings.

METHODS

22 healthy children (11 girls; mean ± SD age: 8.2 ± 0.6 years) provided informed consent to participate in this study. After a warm-up, each participant performed 5 trials each of 13 types of jumping activities. One type was a drop from a 61cm-high box. The other 12 types were performed from the ground and comprised all possible combinations of three factors: direction (vertical, forward, lateral), feet used (1-footed hops, 2-footed jumps), and continuity (single, continuous). All hops were on the dominant foot. In continuous trials, participants performed 2 identical hops/jumps (in opposite directions for the lateral trials) without coming to rest in between. Vertical hops/jumps were as high as possible. Forward and lateral hops/jumps were over marked distances of 80 and 55% of body height, respectively. Lateral hops/jumps were toward the dominant foot. The ground reaction forces acting on the dominant foot during the first landing of each trial were measured at 1080Hz using a force plate. The activity order was counterbalanced across participants. Practice was provided for each activity.

The peak force and peak rate of force increase (determined over a moving window of 4.6ms) on the dominant foot during the first landing of each trial were normalized to body weight and pooled across the 5 trials for each activity. Three-factor repeated-measures ANOVA identified loading differences across direction, feet used, and continuity. Paired *t*-tests with a Bonferroni correction compared the loading for each activity to that of the drop landings. An α of 0.05 was used.

RESULTS AND DISCUSSION

The peak forces during landing were greater for hops than for jumps, were greater for single than for continuous hops/jumps (except in the lateral direction), and were greater for forward hops than for vertical or lateral hops (Table 1). Peak forces during the drop landings exceeded those during all other jumping activities except the single, 1-footed, forward hops.

Similarly, the peak loading rates during landing were greater for single than for continuous hops/jumps (except in the lateral direction) and typically greater for forward than for vertical or lateral hops/jumps (Table 1). Peak loading rates for hops were greater than for jumps only in the lateral direction. Peak loading rates during the drop landings exceeded those during all other jumping activities.

The results make sense. Two-footed jumps allow sharing of the impact forces between the limbs at landing, reducing the peak loading. Continuous forward hops/jumps do not require forward momentum to be arrested upon landing, while continuous vertical hops/jumps likely include a large countermovement after landing, reducing the loading. Forward hops/jumps likely involved greater momentum at landing, hence greater forces and/or loading rates, than did vertical or lateral hops/jumps due to the greater horizontal velocity associated with the greater horizontal distance traveled. Yet, in no hop or jump from the ground did the participants generate energy equivalent to the potential energy at take-off of the drop jump, resulting in smaller impact forces and/or loading rates for these other activities.

CONCLUSIONS

Compared to a variety of other jumps from the ground, single, 1-footed, forward hops produced the largest peak impact loadings in our sample of children. These hops were the only jumping activity from ground level that may produce as great an osteogenic stimulus as drop landings from a 61cm height.

REFERENCES

1. Fuchs et al., *J Bone Miner Res* **16**, 148-156, 2001.

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	Drop	Vertical		Forward		Lateral	
Peak Force (bw):		Single	Continuous	Single	Continuous	Single	Continuous
1-footed hop	–	3.7 ± 0.7 ^{abcd}	3.2 ± 0.5 ^{ad}	4.6 ± 0.7 ^{ab}	3.8 ± 0.7 ^{ad}	3.6 ± 0.5 ^{acd}	3.3 ± 0.3 ^{ad}
2-footed jump	5.3 ± 1.2	3.1 ± 1.0 ^{bd}	2.5 ± 0.6 ^{d}	3.6 ± 1.1 ^{bd}	2.7 ± 0.8 ^{d}	2.7 ± 0.7 ^{d}	2.8 ± 0.5 ^{d}
Peak Loading Rate (bw/s):							
1-footed hop	–	296 ± 147 ^{bcd}	227 ± 97 ^{cd}	449 ± 110 ^{bd}	364 ± 120 ^{d}	277 ±101 ^{acd}	223 ± 61 ^{acd}
2-footed jump	669 ± 190	322 ± 186 ^{bd}	221 ± 115 ^{d}	406 ± 186 ^{bd}	277 ± 126 ^{d}	204 ±107 ^{cd}	194 ± 78 ^{cd}

Table 1: Peak force and peak loading rate during landing as a function of hops vs. jumps, direction, and continuity
^{a} p<.05 vs. 2-footed hop; ^{b} p<.01 vs. Continuous; ^{c} p<.05 vs. Forward; ^{d} p<.001 vs. Drop; bw = body weight