A COMPARISON OF VERTICAL GROUND REACTION FORCES BETWEEN ONE AND TWO-LEG DROP LANDINGS

Steven T. McCaw, Saori Hanaki, Meredith A. Olson, and Joshua J. Kauten

School of Kinesiology and Recreation, Normal, IL, USA
E-mail: smccaw@ilstu.edu    Web: cast.ilstu.edu/mccaw

INTRODUCTION

Both the propulsion phase and landing phase of vertical jumps have been analyzed to quantify loads and understand performance. In addition to affecting performance, mechanical loading affects the osteogenic process and presents an injury risk. Measuring the vertical ground reaction force (vGRF)-time pattern to quantify force magnitude and timing, and the rate of force application (loading rate) provides an initial basis to better understand the loading associated with an activity. Research comparing one and two leg rope jumping (Pittenger et al, 2002) indicated that although the vGRF was higher for one leg landings, magnitude and loading rate values were not double those in two leg landings. Comparisons of the propulsive phase of one versus two leg vertical jumps have suggested that both the bilateral deficit (van Soest et al, 1985) and/or biomechanical factors (Vint & Hinrichs, 1998) affect performance. The purpose of this study was to compare vGRF parameters between one and two leg drop landings in a controlled landing situation.

METHODS

Nineteen healthy college age females (height 167.3 ± 6.1 cm; mass 58.2 ± 5.3 kg; age 20.5±1.2 y) provided informed consent. All participated in athletic activities involving landing. The study was conducted using a repeated measures design. Each participant completed ten trials of one-leg and ten trials of two-leg landing, a total of 20 landings. Participants were allowed to rest at their request. To eliminate order effects, landings were performed in random order. To control landing speed at 2.73 m/s, participants stepped off of a 38 cm take-off box aligned next to the force platform; the only instructions provided in both leg conditions were to “land comfortably”.

Instrumentation: vGRF data were collected from a force platform installed flush with the floor. Landing stability was visually assessed. A typical vGRF-time curve in landing (Figure 1) is characterized by the presence of F1 and F2, peak vGRF values corresponding to the instances of complete forefoot contact and lowest vertical position of the heel, respectively. vGRF data were initially scaled to the participant’s mass. Subsequently, for each trial in each of the different leg conditions, custom software was used to quantify the magnitude of and the time to both F1 and F2, in addition to quantifying loading rate (calculated twice, once as the slope of the vGRF time curve from initial contact to F1, and once from initial contact to F2, units of Body Weights per second (BW/s)).

For each dependent variable, the 10-trial mean value for each participant was calculated in each leg condition and entered into paired t-tests (α = .05) to test the significance of the observed difference between the mean values for the one and two leg landings.
RESULTS AND DISCUSSION

Although mean magnitude values for both F1 and F2 were significantly different, neither value was twice as high in one leg landings compared to two leg landings (F1 values 13.2 ± 3.4 vs 11.7 ± 2.7 N/kg; F2 values 43.0 ± 6.8 vs 29.9 ± 8.7 N/kg, one vs two leg landings respectively). Temporally, in one leg landings both F1 and F2 occurred later after initial contact, although only F1 was significantly different (F1 values 13 ± 3 vs 11 ± 3 ms, F2 values 48 ± 7 vs 47 ± 10 ms, one vs two leg landings respectively). Loading rate (LR) to F1 was not significantly different between the one and two leg landings (110.5 ± 30.6 vs 118.9 ± 44.8 BW/s, respectively), reflecting the inverse effect of the magnitude and temporal changes in F1. However, LR to F2 was significantly higher in one leg compared to two leg landings (97.9 ± 24.3 vs 72.5 ± 33.8 BW/s, respectively). The 135% higher value for LR to F1 in one leg landings reflects the higher force magnitude, since there were no temporal differences in F2 between the two leg conditions.

Since the vGRF reflects the net external force applied to the body, these results suggest that in a controlled situation, a participant must make neuromuscular adjustments during one leg landings to reduce the impulsive load applied to the body to a level similar to that imposed during a two leg landing. Since the adjustments must occur at the ankle, knee and hip joints, quantifying the joint kinetics and energetics would provide insight to the mechanism of neuromuscular control utilized to reduce the impulsive load.

CONCLUSION

Vertical ground reaction force descriptors when landing on one leg are less than double the values exhibited when landing on two legs.

REFERENCES


ACKNOWLEDGEMENTS

This project was funded by a Jump Rope for Heart grant from the Illinois Association for Health, Physical Education, Recreation and Dance, and a Research Grant from Illinois State University.

Figure 1. Typical vertical ground reaction force – time curve.