

# THE INFLUENCE OF JUMP LANDINGS ON DYNAMIC STABILITY

<sup>1</sup> Kathy Liu and <sup>2</sup>Gary Heise

<sup>1</sup> Biomechanics and Movement Sciences, PhD Student, University of Delaware, Newark, Delaware

<sup>2</sup> Biomechanics Laboratory, University of Northern Colorado, Greeley, Colorado  
email: kathyliu@udel.edu

## INTRODUCTION

Dynamic stability is the ability to transition from a dynamic movement to a stable, static condition over one's base of support. Time-to-stability (TTS), based on the diminishing fluctuations of ground reaction forces and COP trajectories, is often used to assess this transitional ability [1]. Experiments designed to assess dynamic stability between different athletic populations [2] and individuals with and without ankle instability [3] are examples of past research efforts.

TTS is often assessed after someone lands on one foot from a forward hop or from a forward-directed vertical jump [2,3]. The influence of different landing directions has received little attention. Recently Wikstrom et al. [4] examined the difference in dynamic stability between hops from different directions by evaluating a postural stability index, not TTS. The index score based on the medial-lateral (ML) ground reaction force was the only measure to show differences between hop directions.

The purpose of the present investigation was to assess the influence of landing direction on TTS, a measure more commonly used among researchers assessing dynamic stability. Specifically, hops from four different directions were examined while each orthogonal component of the ground reaction force was used to calculate TTS measures.

## METHODS

Twenty healthy, recreationally active participants (9 men and 11 women, age =  $28 \pm 4$  yrs, body mass =  $73.3 \pm 21.5$  kg, height =  $173.4 \text{ cm} \pm 10.5 \text{ cm}$ ) volunteered for this study. Participants were asked to complete four hopping tasks onto an AMTI force plate. They used no footwear and landed on their dominant foot which was identified by asking what

foot they would use to kick a ball. The four hopping tasks were: a forward hop at 100% of their leg length (F), a laterally directed hop (L), a medially directed hop (M), and a backwards hop (B). The hopping tasks were assigned in a randomized order and the mean of three trials for each condition was used in statistical analyses.

Ground reaction force (GRF) data were collected at 100 Hz for 10 seconds after landing. TTS was calculated using a sequential estimation technique applied to components of the GRF in the medial-lateral, anterior-posterior, and vertical directions ( $F_x$ ,  $F_y$ , and  $F_z$ , respectively) [1]. Three separate repeated measures analysis of variance were used to assess differences in hop direction. Post hoc within-subject contrasts were completed if statistical significance was found ( $\alpha = .05$ ).

## RESULTS AND DISCUSSION

There were statistically significant differences in landing direction for each measure of TTS. For  $F_x$ , the medial-lateral force, the F and B directions resulted in lower times than the M and L directions (see Figure 1). The opposite result was identified for  $F_y$ , the anterior-posterior force; the M and L directions had lower TTS values than the F and B directions (see Figure 1). When considering the vertical force,  $F_z$ , the F direction had a lower time than the other three directions.

When using GRF data for TTS, hop direction is a clear influence. The mean TTS values for  $F_z$ -based calculations were between 2.0 and 3.0 sec, whereas TTS based on horizontal ground reaction forces resulted in values near 1.0 sec or near 4.0 sec depending on hop direction (see Figure 1). Direct comparison of our results with previous work is difficult because of different protocols and different measures on dynamic stability.

As stated, Wikstrom et al. [4] showed differences in a stability index measure based on medial-lateral force, but no difference when using the anterior-posterior or vertical ground reaction force. They also did not examine a backward hop, but used two “diagonal” directions which were between a forward hop and a lateral hop. In addition, Gerbino et al. [2] reported center acquisition times, a measure similar to TTS, for a “side weight shift” between 3.0 and 4.0 sec which is similar to the higher values reported in the present study.

The multiple directions of hops investigated in the present study are often neglected in dynamic stability research. The large differences in TTS reported here suggest that a more complete profile of dynamic stability should include hops or jumps from more than one direction. Since ankle injuries happen most often in landing from a jump, future work should focus on the dynamic stability of multiple directions of hops. In addition, future research should also focus on mechanisms responsible for dynamic stability and how

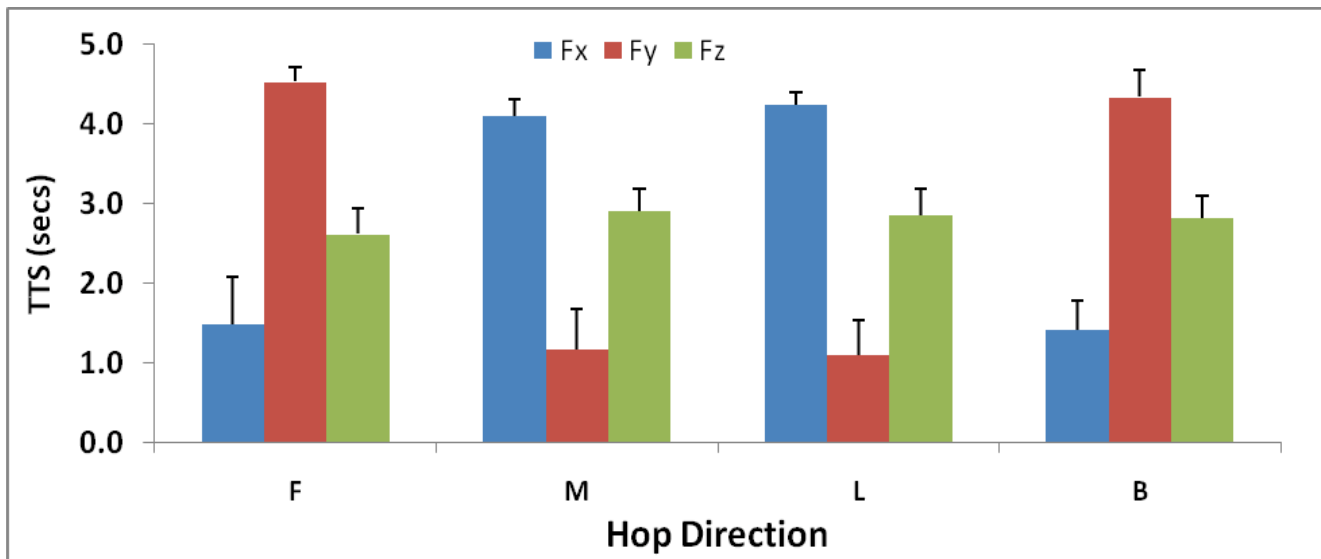
proprioceptive reactions to landings occur at the ankle.

## CONCLUSIONS

Time to stability measures, calculated from the orthogonal components of the ground reaction force, are highly dependent on hop direction. These results suggest that researchers investigating ankle instability and other compromises to a person’s stability should take into account multiple directions of landing when assessing dynamic stability.

## REFERENCES

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3. Wikstrom, EA et al. *J Athletic Training* **41**, 245-250, 2004.
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**Figure 1.** Mean time-to-stability values for all hop directions Forward, Medial, Lateral, Backward using sequential averaging technique of Colby et al. (1999) applied to Fx, Fy, and Fz. Error bars represent SD among 20 subjects. Statistically significant differences between hop directions are identified in the text.