College of Health Sciences
Student Research Grant Proposal 2015
Cover Sheet

Student Taylour Hinshaw **Phone number:** 307 299 7410 **Email:** thinsha1@uwyo.edu

and

Faculty Advisor Dr. Boyi Dai

College unit Division of Kinesiology and Health

Title of Research Project

The effect of mid-flight trunk motion on landing mechanics

Budget Request: $ _____1000_____

Detailed Budget Proposal (see restrictions above)

An estimate of 30 subjects (15 male, 15 female) will be recruited for this study; 30 subjects paid $15 each will result in a total requested budget of **$450**.

Approximately 40 reflective markers will be placed on a participant for the data collection. Reflective markers may need to be replaced regularly to ensure sufficient reflection. $**400** is requested to purchase 20 additional reflective markers.

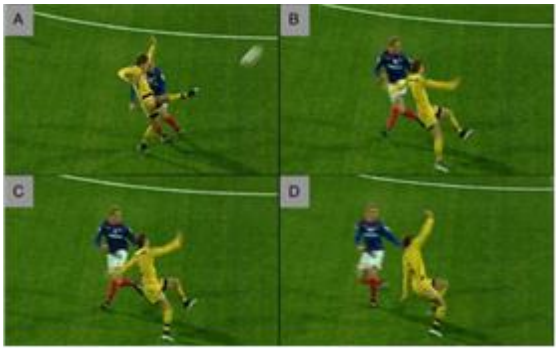
Double-sided tapes will be used to attach the markers to participants. **$150** is requested to purchase double-sided tapes.

INTRODUCTION

The anterior cruciate ligament (ACL) is one of the most commonly performed orthopedic surgeries (Ferretti *et al*, 2010). This common injury is one that has led to a large push in the biomechanical field and the study of non-contact ACL injuries (Boden *et al*, 2000). Researchers have found that using a 'soft landing technique' or essentially reaching a deeper maximum knee flexion angle led to decreased impact forces when compared to a 'stiff landing technique' where the participants landed more upright (Devita & Skelly, 1992). One's muscular strength plays a major role in single-legged stop-jump task with importance placed on equal strength between quadriceps and hamstrings (Nagai *et al*, 2013). Less strength may lead to a decrease in knee flexion angle. Single-leg landings are associated with greater ground reaction force and a decrease at initial and maximum knee flexion (Yeow, Lee & Goh, 2010). This suggests that the ACL is at a higher risk of injury in single-leg landings.

Although the subject of ACL injures have been well researched, a lot of focus is put on the lower extremities while little information is available regarding trunk position at the time of injury. Previous studies have shown that forward trunk lean can actually place less force on the ACL during single-leg squats demonstrating the importance of trunk lean in relation to the knee (Kulas, Hortobagyi & Devita, 2012). As shown in two figures below, video analysis of ACL injury events showed that individuals typically demonstrate unbalanced trunk motion during landing before the ACL was injured.

Stuelcken et al. (2015)



Walden et al. (2015)

The above figure on the left was taken from a study conducted on videos of elite, women netball players (Stuelcken *et al*, 2015). Sixteen videos of ACL injuries were recorded and analyzed, showing that when the trunk was altered (through either a perturbation or non-contact), landing was unbalanced and resulted in an ACL injury. The figure on the right shows a video analysis taken from 25 other videos of non-contact ACL injuries found in professional male football players (Walden *et al*, 2015). It can be seen in both of the figures above, that when the ACL injury occurred, the trunk was in motion and out of line with the rest of the body. This evidence suggests the importance of quantifying how trunk motion during mid-flight may affect landing mechanics.

There has been previous representation of quantifying trunk motion in relation to the knee in an overhead badminton stroke (Kimura *et al*, 2014). Kimura *et al* (2014) found that lateral trunk bending was associated with excessive knee valgus moment in single-leg landing. The study by Kimura et al. (2014), however, analyzed different body segment separately and did not however quantify the mechanism of how trunk motion affect landing mechanics. Based on Newton's first law, during a vertical jump task, the center of mass of an individual will stay in a

vertical line because there is no external force acting on the individuals in the medial-lateral direction. As such, if the trunk moves to one side, a part of the body has to move to the other side to maintain the center of mass in the vertical direction. As shown in two figures above, individuals are likely to move one side of the lower extremity to the other side. As a consequence, this side of lower extremity could not be utilize for landing and will result in a unilateral landing pattern and may increase the risk of ACL injuries. A previous study has found that single-leg landings result in a decreased knee flexion angle and an increase in knee valgus angle as compared to double-leg landings (Leporace *et al*, 2010). These results from single-leg landings would put more stress on the ACL leading to a higher chance of injury.

Therefore, the purpose of the current study is to quantify the effect of medial and lateral trunk motion during mid-flight on landing biomechanics through center of mass analysis. It is hypothesized that medial and lateral trunk motion during mid-flight will result in lateral motion of one leg and lead to a single leg landing pattern, which is associated with greater impact forces and decreased knee flexion angles.

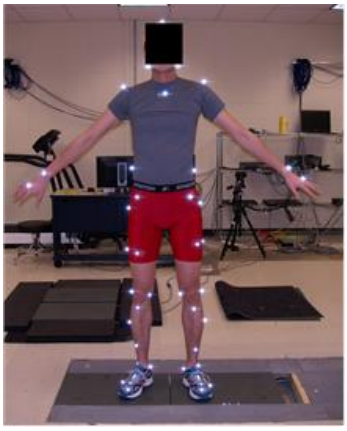
APPROACH

Subjects

A of 30 total recreational athletes (15 male and 15 female) who have experience playing sports that involve jump landings and are physically active will be recruited. Individuals will not be allowed to participate if they (1) have not participated in a sport that involves jump landing. (2) are not physically active. (3) have had a major lower extremity injury or minor injury that kept one from participating in physical activity for more than 2 weeks in the previous 6 months. (4) possess cardiovascular, respiratory, neurologic, or other conditions that prevent participation in maximum effort. (5) are allergic to latex or adhesive, (6) is pregnant. The IRB of the current proposed study is in preparation.

Procedure

A standard warm-up procedure will be completed before the start of the study. Clothes and shoes will be provided. Participants will then be coved with markers from head to toe (seen in picture below) so that the center of mass for each body segment can be calculated. This will then allow the researchers to evaluate how the overall body's center of mass compensated for trunk lean and single-leg landings.



Marker Placement

Subjects will be asked to complete a series of jumps given in a random order. Below is a standard jump with no additional trunk motion during mid-flight. Subjects will be instructed to start with one foot on each of the two forceplates, then jump straight up and land in the same spot with one foot landing on the same forceplate.

Landing without trunk motion during mid-flight

Subjects will also be instructed to jump up into the air and lean either left or right while still trying to land on the same place as they had taken off from.

Landing with trunk motion in one direction during mid-flight

Landing with trunk motion in another direction during mid-flight

Subjects will have a minimum of practice trials and three official trials will be recorded for each landing conditions. A minimum of 30 seconds will be provided between trials to avoid fatigue. Participants' motion will be captured using eight Vicon high-speed cameras at 160 Hz (Vicon Bonita 10, Oxford Metrics Ltd, Oxford, UK), and participants' impact ground reaction force will be recorded suing two Bertec force plates at 1600 Hz (4060-10, Bertec, Columbus, OH).

Data Reduction and Analysis

The motion data and force data will be filtered using a low-pass filtered at 15 Hz and 100 Hz, respectively. Markers will be used to define body segments and used to calculate the center of mass of each segment and the total body. Knee flexion angles during landing will be calculated as the Cardan angles between the thigh reference frame and tibia reference frame. The

peak vertical ground reaction during landing will be extracted for analysis. The calculations will be performed using customized subroutines developed in MATLAB 2009a (MathWorks Inc. Natick, MA).

The independent variable is the landing condition (no trunk motion vs. medial trunk motion vs. lateral trunk motion). The dependant variables include the trunk center of mass location, medial leg center of mass location, lateral leg center of mass location, and total body center of mass location at initial contact. The dependant variable also include the peak vertical landing forces and knee flexion angle at initial contact and peak knee flexion angle during landing for both legs.

Repeated measure analysis of variables will be performed for each dependent variable, followed by paired t-tests. A type-I error rate was set at 0.05 for statistical significance. Statistical tests will be performed using IBM SPS Statistics 22 (IBM Corporation, Armonk, NewYork).

SIGNIFICANCE

Based on the previous research, the current investigators expect to find that trunk motion will cause single-leg landings and result in more stress placed on the ACL. This may provide information to understand how ACL injury risk during landing may be elevated when the trunk motion is altered during mid-flight. The findings are also necessary to add to intervention programs that teach individuals how to land safely when their torso is altered in the air. This study may also contribute to future research designed with trunk variations while in the air.

FUTURE PLAN

The proposed research will be the current investigator's plan for a Master's Thesis. This will be a continuation of previous research done during her Bachelor's Degree and previous research done by the supervising faculty. A potential follow-up study will be evaluating the effect of modified landing techniques such as soft landing or landing with increased joint range of motion on landing mechanics when the trunk motion is altered during mid-flight.

APPENDICES

Proposed budget with justification

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Bibliography

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Mar 03, 2016

Dear College of Health Sciences Research Committee,

I am writing this letter to express my sincere willingness to supervise Taylour Hinshaw's research project titled "the effect of mid-flight trunk motion on landing mechanics." Taylour is a first-year Master's student and also a graduate assistant in the Division of Kinesiology and Health. As Taylour mentioned, anterior cruciate ligament (ACL) injuries are very common in athletes and can cause devastating consequences. Individuals following ACL injuries usually demonstrate decreased knee strength and proprioception and increased risks for ACL re-injury and knee osteoarthritis. The mechanisms of ACL injuries, however, are still not clear. As unbalanced trunk motion is commonly observed during ACL injuries, but how trunk motion during mid-flight may affect the loading of the ACL is unknown. Taylour's study is novel and significant because it will be the first to quantify how medial-lateral trunk motion may affect landing mechanics through center of mass analysis. This information will be very important for developing future injury prevention strategies.

Taylour has been working in the biomechanics lab since she was a junior at the University of Wyoming. As listed below, Taylour presented in national conferences and has one journal article in press and multiple manuscripts in preparation. What Taylour has done as a first-year Master's student is excellent. Taylour plans to graduate in May 2017. I believe this project will be a great thesis work and prepare her well for future practice and research. As Taylour's advisor, I am willing to assist her in research design, data collection, data process and analysis, and writing for this project. Please do not hesitate to contact me if you have any questions.

Fisher, H., Stephenson, M.L., Graves, K.K., **Hinshaw, T.J.**, Smith, D.T., Zhu, Q., Wilson, M.A., Dai, B. (in press). The relationship between force production during isometric squats and knee flexion angles during landing. *Journal of Strength and Conditioning Research*.

Cosgrove, M.J., Stephenson, M.L., **Hinshaw, T.J.**, Overton, K.L., Roberts, A.L., Meyer, E.A., & Dai, B. (2015). Age and sex effects on force asymmetry during jump and push-up tasks in youth soccer players. Poster at American Society of Biomechanics Meeting, Columbus, OH.

Stephenson, M.L., Fisher, H., Graves, K.K., **Hinshaw, T.J.**, Dai, B. (2015). Isometric squat peak force in range of knee flexion angles strongly related to countermovement jump peak force. Poster at American Society of Biomechanics Meeting, Columbus, OH.

Stephenson, M.L., **Hinshaw, T.J.**, Trumble, T.A., Zhu, Q., Dai, B. (2015). The effects of stimulus timing on the kinetics of a directed jump landing. Poster at American Society of Biomechanics Meeting, Columbus, OH.

Fisher, H., Stephenson, M.L., Graves, K.K., **Hinshaw, T.J.**, Dai, B. (2015). The relationship between force production during isometric squats and knee flexion angles during landing. Oral presentation at International Society of Biomechanics in Sport Meeting, Poitiers, France.

Respectfully,

Boyi Dai