Introduction:
Noncontact anterior cruciate ligament (ACL) injuries are increasing in the US, with over 207,000 ACL reconstructive surgeries being performed annually.1.2 Soccer has not been immune from this and has seen a gender gap where females are twice as likely to tear their ACL. In competition, women soccer players tend to commit fewer falls but play at the same intensity as males.3 This trend presenting the difference in ACL injury occurrence with the addition of fewer falls between genders makes us believe there is a significant biomechanical difference in the between male and female soccer players. Research needs to be done to understand the differences in biomechanics between male and female soccer players.
Research has previously been conducted to examine how jump landing mechanics can assess ACL tear risk.4-10 Typically, countermovement jumps and drop jumps are used for such assessments.5.7 These tests have had some success in stratifying ACL tear risk but may be lacking in external validity due to never having a game-related aspect. Many ACL tears are noncontact for both males and females and occur while playing in a game or practice, meaning the athlete is likely not focusing on movement technique. This prompts us to want to examine the biomechanics of movement between genders using the secondary task of heading a soccer ball to see if there is a significant difference. Given the discrepancy in ACL injury rates between male and female soccer players, we wanted to examine if a secondary task alters the jump mechanics of females more than males. Previous studies have examined the sex-based differences in landing mechanics when performing jump assessments.5,7,11-13 These studies did not incorporate the addition of a cognitive load on the participant. Other research has been conducted to assess how the secondary task of counting and retaining numbers impact jumping performance14.15 In both of these studies, males and females were included, but there was no difference between genders. The aim of the current study was to examine whether the addition of a secondary task impacted jumping landing kinematics, identified as movement patterns that increase the risk of an ACL tear.16-18 Within the past year, researchers have examined the impact of incorporating the secondary task of a header in soccer players with only a drop vertical jump.19,20 This study included both genders, but did not examine the differences between genders. The present study examines how the secondary task of heading a soccer ball will impact jumping and landing kinematics and kinetics associated with ACL injury risk between male and female soccer players through the use of countermovement jumps and drop vertical jumps.

Hypothesis:
Adding the sport-specific secondary task of heading a soccer ball will alter the landing kinematics and kinetics known to increase ACL injury risk greater in females than males in common jump assessments.

Methods:
Participants were recruited from the men’s and women’s collegiate soccer teams at the University of Mount Union (Men: N=10, 1.77±0.07m, 77.26±5.13kg; Women: N=15, 1.54±0.06m, 60.62±6.12kg). Approval was obtained from the university IRB prior to the research study. After gaining informed consent and biometric information, participants had twenty-six 2mm reflective markers placed on their locations that allowed for the 3D modeling, using the ProCue (Vicon Nexus 2.12, Denver, USA). All jumps and landings occurred on 2 force plates (AMTI, Watertown, USA) embedded in the floor. The landing phases were assessed. For the DVJ trials, there were 2 landing phases, one from the drop-off of the box and one landing back from the jump. There was one landing phase during the CMJ. Vertical ground reaction force (vGRF) landing asymmetry was calculated following the “Bilateral Asymmetry Index” guidelines from Bishop et al.21 The equation is as follows:

$$\text{BIA} = \frac{2 \times (\text{Max} - \text{Min})}{\text{Max} + \text{Min}} 
$$

Positive values indicate asymmetry in the direction of the stronger limb. The Symmetry Index (SI) was calculated as follows:

$$\text{SI} = \frac{\text{Max} - \text{Min}}{\text{Max} + \text{Min}} 
$$

Positive values indicate asymmetry in the direction of the stronger limb.

Kinematic data were extracted using Vicon ProCue software while force plate data were extracted and assessed within Microsoft Excel.

Data Analysis:
The data was analysed using SPSS version 28 (IBM, New York, USA). Paired t-tests were used to compare differences in knee flexion changes between males and females. Analysis was run to determine the differences between gender and without the incorporation of the secondary task. Significance was set at p<0.05.

Discussion:
Our preliminary findings show that the addition of a specific (SS) task to the DVJ and the CMJ lead to some kinematic and kinetic differences in both genders but did not examine an other ACL study.22 Researchers rely on lab-based movement assessments to identify athletes who may be at increased risk for injury. Previous research has identified increased knee valgus, knee internal rotation, hip adduction, and decreased hip and knee flexion during landing as the variables which are strongly associated with injury.23 However, these assessments may lack transfer to the sporting environment as they do not include sport-specific events. In soccer, a repeated landing situation is common. As such, we added a SS task to the CMJ, which may better metrics a true soccer event of jumping to head a soccer ball. Most of our results suggest a “header” landing following the SS task. To our knowledge, no study has examined the differences between gender and cognitive load jump assessments. We found that adding a SS task there was no difference between genders. This was due to the variable by variable between subjects in both the male and female group. In both groups, we saw indications that the SS task led to increased SI in ACL injury predictors but no difference between males and females in these categories. We believe that this is due to the variability by variable between subjects. The variability is due to those that are “thinkers” from the SS task. To see if there are any greater risk additional work will be done in this study to monitor the injury status of those who were classified in this group. When examining the differences in vGRF variables between genders with the addition of a SS task to jump assessments we observed an increase in asymmetry in both genders but no significance between genders. In doing so, we did observe a greater increase in asymmetry with men compared to women. Asymmetry during sport-specific tasks has been linked with enhanced knees and.

Taken together, our data suggest that adding a SS task to jump assessments may increase the injury prediction values of these tests, but that gender is not more affected, although prospective cohort studies would need to be done to confirm this.

In conclusion:
• Continue logging the injuries of participants to see if those whose landing mechanics are negatively affected the secondary task are more likely to have a knee injury.
• Investigate if similar findings will occur across other sports, such as basketball, and examine their gender differences.

Acknowledgments:
Special thanks to the participants of this study. Also, to Zach Corso, A. Tyler, Katlyn Polsky, and Isabelle Bobe for help in collecting this data.

References:
Science Citation Index for complete reference list.

Results:
As shown in Figure 3A, there was no significant difference between groups in vGRF during landing 1 of the DVJ, F(1,26)=1.654, p=0.187. There was a significant difference in vGRF during landing 2 of the DVJ, F(1,26)=4.736, p=0.005 (Figure 3B). Post-hoc analysis found a significant difference between male DVJ-SH and female DVJ, p=0.002.

The difference in knee flexion angle from DVJ to SH was assessed compared between males and females for landing 1 and landing 2 of the DVJ. No significant differences were seen between males and females for either the dominant or non-dominant limbs, p=0.053 (Figure 4A and 4B).

As shown in Figure 5A, there was no significant difference between groups in vGRF in the CMJ during landing 1, F(1,26)=0.005, p=0.944. There was a significant difference in vGRF in the CMJ during landing 2 of the DVJ, F(1,26)=4.736, p=0.005 (Figure 5B). Post-hoc analysis found a significant difference between male CMJ-SH and CMJ, p=0.002. Gender differences were found between male DVJ-SH and female DVJ, p=0.002. The difference in knee flexion angle from CMJ to DVJ was compared between males and females. No significant differences were seen between males and females for either the dominant or non-dominant limbs, p=0.055 (Figure 5C).

Figure 1: (A) Conventional Gait Model 2.3 marker placement and (B) modeled in the Vicon Nexus software.

Figure 2: (A) Representative vGRF data from a soccer-specific drop vertical jump (DVJ-SH). Solid arrows represent the asymmetry for landing 1 (L1) in this example; the dashed arrows represent the asymmetry for landing 2 (L2) in this example. (B) Representative vGRF data from the landing phase (L) of a soccer-specific countermovement jump (CMJ-SH).

Figure 3: Graphical representation of vGRF asymmetry data for DVJ-SH and DVJ trials, mean and standard deviation for males and females. (A) Landing 1 during the soccer-specific drop vertical jump (DVJ-SH) and drop vertical jump (DVJ); (B) Landing 2 during the DVJ-SH and DVJ.

Figure 4: Change in knee flexion between DVJ-SH and DVJ for the initial contact points. (A) Difference in knee flexion in initial contact between DVJ-SH and DVJ for L1 between dominate and non-dominant limbs in males and females. (B) Difference in knee flexion in initial contact between DVJ-SH and DVJ for L2 between dominate and non-dominant limbs in males and females.

Figure 5: Analysis for CMJ trials including: (A) graphical representation of vGRF asymmetry data for CMJ-SH and CMJ trials; mean and standard deviation for males and females and (B) change in knee flexion between CMJ-SH and CMJ at initial contact between dominate and non-dominant limbs in males and females.

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How Does the Secondary Task of Heading a Soccer Ball Impact Jumping Kinematics and Kinetics? Brydon Lazarraga and Tomás Barrett Department of Exercise, Sport, and Nutrition Sciences, University of Mount Union, Alliance, OH, 44602, USA