PREDICTORS OF FATIGUE INDUCED ANTERIOR CRUCIATE LIGAMENT INJURY RISK FACTORS IN RECREATIONALLY ACTIVE FEMALES

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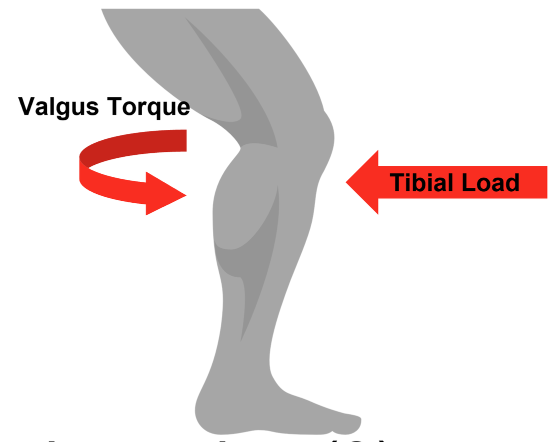
INTRODUCTION

- Anterior cruciate ligament (ACL) injuries occur when excessive loads are placed on the ligament and most commonly **occur when an anterior tibial load is combined with valgus motion** (2).



- **Fatigue** lowers athletes' neuromuscular proprioception (3), increasing the potential for producing damaging joint forces.
- **Females** tend to have greater valgus, and higher rates of ACL injuries (1).
- Limited evidence exists surrounding variables associated with fatigue related increases in knee valgus.

PURPOSE

The purpose of this study was to determine whether a fatiguing drop jump protocol **1)** increases knee valgus and **2)** determine specific variables related to increased knee valgus

Hypothesis: It was hypothesized that fatigue would increase knee valgus, with knee joint laxity would be the largest predictor of fatigue related knee valgus.

METHODS

Table 1 Displays the dependent variables.

Peak GRF (pre, post)	Echo intensity
CSA (hamstrings, quadriceps)	Hamstrings:Quadriceps CSA
ACL size (pre, post)	Knee joint laxity (pre, post, diff)
Valgus diff	Jump height

Note: **GRF** = ground reaction force; **CSA** = cross sectional area; **Knee joint laxity** = anterior-posterior displacement of the tibia relative to the femur; **Echo intensity** = method to quantify muscle quality; **Pre** = pre fatigue protocol; **Post** = post fatigue protocol; diff = post – pre.

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METHODS CONTINUED

Table 2 Participant demographics of 10 recreationally active females.

Age	Height	Weight
24.33 ± 5.81 years	167.33 ± 4.93 cm	70.90 ± 10.43 kg

- **ACL Size:** Two images were obtained using techniques described in figure 2. ACL size of the full diameter was measured using ImageJ and averaged and for analysis pre and post fatigue.
- **Muscle Cross Sectional Area (CSA) & Echo Intensity:** Two images of the hamstrings and quadriceps were obtained using panoramic ultrasound. CSA and echo intensity was calculated using ImageJ to quantify muscle size and muscle quality, respectively.
- **Knee Joint Laxity:** Defined as the anterior-posterior displacement of the tibia relative to the femur and is measured using processes outlined in figure 1 pre and post fatigue. The averaged measurements were used for analysis.

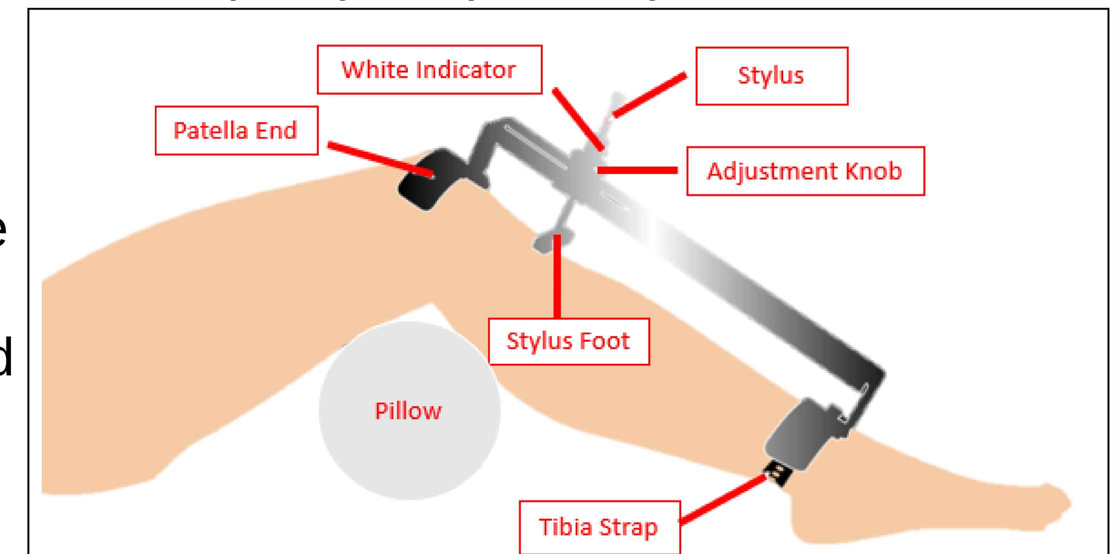

Figure 1 The arthrometer is strapped to the anterior portion of the shin and affixed to the proximal part of the patella. The researchers will perform the Lachman test by pulling the posterior part of the tibia. KJL is measured by quantifying the displacement of the stylus (mm).

- **Kinetic Data:** Relative peak vertical ground reaction force (GRF) and jump height was obtained using dual force platforms, and peak knee valgus was processed from motion video capturing using a custom MATLAB code. The data were averaged across the first five drop jumps (*pre fatigue*) and last five drop jumps (*post fatigue*).
- **Fatigue Protocol:** Drop jumps repeated every 20 seconds until participants could no longer achieve 80% of their pre jump height.
- **Box Height:** Set to 90% of the participants maximal jump height.
- **Statistical Analysis:** Data were analyzed using a stepwise linear regression model (α<0.05).

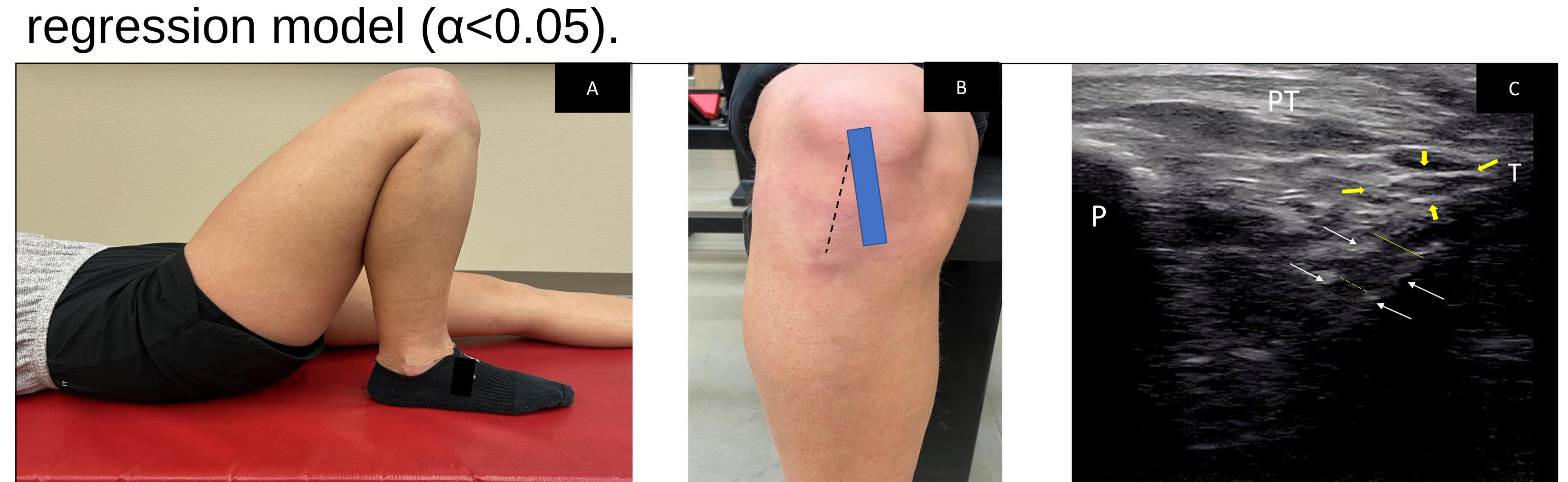

Figure 2 **A)** Demonstrates how the participant lies supine with their right knee flexed to 90°. **B)** Demonstrates the probe position for visualizing the ACL. The blue rectangle represents the probe, and the black dotted line represents the patella tendon. Probe is placed above the patella tendon and rotated 30°. The inferior part of the probe is medial to the patella tendon and the superior part of the probe is lateral to the patella tendon. **C)** Ultrasound imaging of the ACL at the long-axis view of the infrapatellar area. The ACL can be viewed between the white arrows and the dotted line represents the anteromedial bundle diameter and the solid line represents the full ACL diameter. The yellow arrows outline the transverse ligament which is used as a guide to identify the ACL. PT, patellar tendon; P, patella; T, tibia.

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RESULTS

- **Knee Valgus** significantly increased pre (-5.94 ± 2.26°) and post (-6.68 ± 2.25°) fatigue (p = 0.047).
- Three variables (**pre peak ground reaction force, hamstring echo intensity, and post ACL size**) predicted the fatigue related increases in knee valgus. Results are presented in table 3.

Table 3 A linear model of predictors of knee valgus post fatigue.

		B	SE B	ß	p
Step 1	Constant	3.795	2.551		=0.163
	Pre Peak GRF	-2.798	0.66	-0.848	=0.004
Step 2	Constant	11.433	2.865		=0.007
	Peak GRF	-3.317	0.462	-1.006	<0.001
	Hamstrings EI	-0.085	0.026	-0.449	=0.018
Step 3	Constant	-8.308	3.975		=0.091
	Peak GRF	-1.533	0.395	-0.465	=0.012
	Hamstrings EI	-0.102	0.012	-0.539	<0.001
	Post ACL size	2.063	0.395	0.650	=0.003

Notes. R^2 = 0.720 for step 1; ΔR^2 = 0.177 for step 2; ΔR^2 = 0.087 for step 3. B = unstandardized coefficient; SE = standard error of B; ß = beta (standardized coefficient); statistical significance set at α<0.05. GRF = ground reaction force; EI = echo intensity.

CONCLUSIONS

Increased knee valgus was predicted by:

72% Pre Peak GRF; 17% Hamstring Muscle Quality; 8.7% Post ACL size

= 98.4% variance explained by these variables

PRACTICAL APPLICATIONS

To reduce ACL injury risk, strength and conditioning practitioners should focus on decreasing peak ground reaction forces during landing movements. Additionally, proper hamstring training should be emphasized to improve muscle quality and size of the surrounding ligaments.

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