INTRODUCTION: Greater joint laxity has been implicated as a risk factor for anterior cruciate ligament (ACL) injury. However, the mechanism(s) by which knee laxity modifies injury risk is not known. We compared participants with above average vs. below average varus-valgus (LAXVV) and internal-external (LAXIER) rotation knee laxities on transverse and frontal plane hip and knee motions during drop jump landings. As previous work has observed sex differences in LAXVV and LAXIER[1], we examined males and females separately.

MATERIALS AND METHODS: A total of 96 (52 F: 22±3 yrs, 163±6 cm, 60±8 kg; 44 M: 22±3 yrs, 178±10 cm, 81±14 kg) recreationally active (2.5 – 10 hrs/wk), non-smoking participants with no history of knee injury, and no known connective tissue disorders were measured for non-weight bearing LAXVV (0-10Nm torque) and LAXIER (0-5Nm torque) using the Vermont Knee Laxity Device (VKLD, Burlington, VT).[2] (Females were tested during days of menses). Within each sex mean LAXVV and LAXIER were calculated, and subjects were classified with above or below average values on each measure. Subjects were included in this study if they were classified as having above average values on both LAXVV and LAXIER (LAXHIGH) or below average values on both LAXVV and LAXIER (LAXLOW). In the final sample, 18 LAXHIGH females (10.9±2.7° LAXVV, 19.9±4.3° LAXIER) were compared to 17 LAXLOW females (16.3±2.7° LAXVV, 34.5±4.8° LAXIER), and 17 LAXHIGH males (7.0±0.8° LAXVV, 14.2±4.1° LAXIER) were compared to 16 LAXLOW males (11.5±1.8° LAXVV, 27.9±4.9° LAXIER). On the same day as laxity testing, biomechanical analysis of the dominant lower extremity during the initial landing phase of a drop jump was completed. Transverse and frontal plane hip (HIPVV, HPIER) and knee (KNEEVV, KNEIER) motions during the landing phase (initial contact to peak center of mass displacement) were calculated using Euler sequences and normalized to 101 data points. Separate (2 group) x 99 (time) repeated measures ANOVA compared LAXLOW and LAXHIGH groups on HIPVV, HIPIER, KNEEVV, and KNEIER for each sex. For significant group by time interactions, independent t-tests compared groups at each %increment. Alpha level was set at P<.05.

RESULTS: When comparing hip and knee kinematics between LAXHIGH and LAXLOW females, group (P=.041) and group by time effects (P=.002) were observed for HIPER and significant group by time effects were observed for HIPER (P<.001) and KNEERV (P=.004). No group (P=.633) or group by time effects (P=.674) were noted for KNEIER. LAXLOW females averaged 4.7° of hip abduction while LAXHIGH females averaged 1.6° of adduction across the entire landing phase, with angles being significantly different between 0- 20% and 40-90% of the drop landing (Figure 1). While clear movement pattern differences were observed between groups for HIPER, post hoc analyses revealed no group differences at any %increment (all P >.05) (Figure 2). For KNEERV, LAXLOW knees initially landed in varus (0.7 - 3.4°) while LAXHIGH knees landed in valgus (1.8 - 3.1°) (P<.05, 0-13% of drop landing phase)(Figure 3). While LAXHIGH females tended to return to greater valgus than LAXLOW females later in the landing phase, no other pairwise differences were significant (P-value range = .055 - .833 from 14-99% of the drop landing phase). When evaluating males, LAXLOW males remained in more hip abduction throughout the landing phase (+4.4 deg vs. -0.85deg, P=.029), and these differences were not time dependent (P=.675). There were no differences between LAXLOW and LAXHIGH males for HIPER, KNEERV or KNEIER (All P-values > .642).

DISCUSSION: Hip and knee kinematics were different between LAXHIGH and LAXLOW, particularly in females. Early in the landing phase, LAXLOW females were positioned in more hip adduction and knee valgus and moved towards greater hip internal rotation compared to LAXLOW females, then remained in more hip adduction throughout much of the landing (Figures 1-3). Such integrated positioning during landing (greater knee valgus, hip internal rotation and hip adduction) is often considered to be a dynamic alignment associated with ACL injury risk. Thus, female knees with greater knee laxity may be at a mechanical disadvantage early in the landing phase where injury is thought to occur. While similar differences in HIPER between LAXLOW and LAXHIGH males were observed, both in pattern and magnitude, no other group differences were observed in males. This may in part be due to the overall lower magnitude of joint laxity in males. It may be that a critical level of laxity is necessary before hip and knee motions are affected. Future work should compare sexes matched on laxity values.


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