BIOMECHANICAL ANALYSIS OF JUMPING COMPARING LOW- AND HIGH- ACL INJURY RISK GROUPS: IDENTIFYING POSSIBLE MECHANICAL RISK FACTORS

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INTRODUCTION

It is well known and documented that anterior cruciate ligament (ACL) knee injuries occur more frequently in women, at a rate of 4-8 times that of men [1]. Of the 30,000-100,000 ACL injuries reported in various years, most injures were a result of a non-contact mechanism and sports such as soccer, basketball, and volleyball, report the highest prevalence of ACL injuries especially when compared to males in the same sports [2, 3]. Research associated with knee injuries in females has observed hormonal, neuromuscular, and anatomical differences in men and women [4]. What has not been reported is why certain groups of athletes have a higher incidence of injury than others, or if it is due to training and teaching techniques. If dancers and cheerleaders also jump, why are they less likely to injure their knees? The purpose of this study was to compare kinematics and kinetic data from low- and high- ACL injury risk groups, and controls, to identify possible mechanical risk factors.

METHODS

Thirty-six female collegiate undergraduates volunteered for this study; however, only 32 (m=20±2.3yrs) completed the study. Subjects were placed in one of three groups: high-risk (volleyball players, n=11), low-risk (dancers & cheerleaders, n=12), and controls (non-athletic, n=9). All participants completed an informed consent and medical questionnaire.

Each participant performed 3 vertical jumps at maximal effort with joint markers on the right and left legs placed at the hip, knee, ankle, heel and toe. Each participant faced the same direction and had only the right foot on the Bertec force platform when jumping. The jumps were videotaped using three cameras, two anteriorly and one posteriorly positioned relative to the subject. The video was digitized and then filtered and processed to calculate flexion/extension at the knee and ankle, knee varus/valgus, jump height, and jump time using Peak Motus® 8. The force data was synchronized with the kinematics data to calculate peak forces during the loading and landing phases of the jump. The force plate collected at 600 Hz, while the cameras collected data at 60 Hz.

RESULTS AND DISCUSSION

A 3 X 9 (group X measure) ANOVA found significant differences ($p<0.05$) between the groups for all but 2 of the dependent measures (Table 1). Post-hoc tests revealed the high-risk group to be significantly different from both the controls and the low-risk group for the kinematic measures (dorsi/plantarflexion at load & land, knee flexion at load & land, & jump time) (Figure 1), while the low-risk group was significantly different from the high-risk and controls for the kinetic measures (GRF at load & land). Measures of knee varus and valgus were not significant.

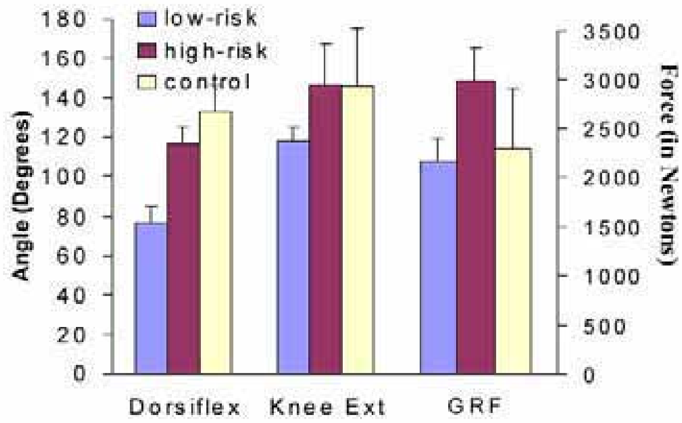

Figure 1: Maximal dorsiflexion, knee extension and ground reaction force during the landing phase of the jump.

This study revealed several differences between the three groups. The high-risk group was observed to load the least out of the three groups (knee angles: loading 120 deg, landing 147 deg), yet had longer jump times (0.48s vs. 0.42s). This is possibly due to training, needing to get to the net and quickly jump high to spike or block the ball. This landing style transmits a high amount of force to the knee and puts excessive stress on the ACL. The high-risk group also had higher GRF (loading: 2128 N, landing: 2979 N) than the low-risk group (loading: 1936 N, landing: 2165 N). These high forces could be attributed to the higher prevalence of ACL tears. The similar GRF for loading and landing in the low-risk group could be due to their training and teaching. Dancers are taught to go through the same flexion/extension path and depth during loading and landing. This could indicate why they have fewer ACL injuries compared to the high-risk group. The low risk groups must make jumps look smooth and symmetrical, while the high-risk athletes have a responsibility to make an athletic play regardless of how it looks.

CONCLUSIONS

Prevention programs have been developed to retrain females' firing patterns, increase hamstring strength, and improve jumping and landing mechanics to reduce the number of incidences and risk of injury. The research presented here supports the need for preventative jumping programs to decrease the ground reaction forces during landing and increase joint flexion, to reduce risk factors.

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	Dorsiflexion (degrees)	Knee Flexion (degrees)	GRF (Newtons)	Jump time (seconds)
Load	L74±9, H88±9, C70±13	L105±17, H120±18, C99±8	L1936±223, H2128±348, C1685±610	L0.416±.04, H0.479±.04, C0.443±.07
Land	L76±8, H116±20, C133±29	L118±13, H147±18, C146±14	L2165±314, H2979±325, C2296±728	

Table 1: Means and standard errors for the low-risk (L), high-risk (H), & control (C) groups for the measures with significant findings.