Literature Review

1. "The relationship of hamstrings and quadriceps strength to anterior cruciate ligament injury in female athletes"

Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC9928500/

The study included 22 women who suffered from non-contact ACL injuries from soccer and basketball. Soccer: 16 and basketball: 6. Had a female control group and also compared to injured and non-injured men. Females who participate in sports that are considered high risk of injury suffer from an ACL injury at a 4 to 6-fold greater rate than males, which is a given smaller range than given to us in our original writeup. It was reported that females utilize increased quadriceps activation without matched increases in hamstrings activation as they perform drop landings, which inevitably leads to increased lower extremity injuries. This study's approach focused on controlling for potential confounding variance between sports, maturational status, and individual testing measurements. After an ACL injury, women suffer a loss of hamstring strength but also do not lose quadriceps strength. Leading to the conclusion that decreased relative hamstrings strength and recruitment may be a potential contributing mechanism to ACL injury in high-risk female athletes.

2. "Physical Performance Assessments of Strength and Power in Women Collegiate Athletes"

Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC8439680/

Muscular strength is a very important aspect of athletic performance but also very important in reducing the risk of injury for athletes. Sport specific skills are developed through an increase the ability of an athlete to produce force, and strength in the areas stressed most by these sport specific skills provides stability to combat injuries. This specific study assesses division 3 women athletes in 4 different sports: soccer, volleyball, field hockey, and softball. All athletes within the study tested their vertical jump, 1-RM back squat, and standing long jump (with exception of volleyball). Softball players, on average, had a larger value for the 1-RM back squat than field hockey, soccer, and volleyball players. They also had a larger value, on average, of vertical jump than field hockey and soccer players. Volleyball players had a statistically significantly greater 1-RM back squat than soccer players. Similarly, volleyball players along with softball players had greater vertical jumps than soccer players who had higher vertical jumps than field hockey players. There was not a significant difference in long jump numbers between the sports. The results for field hockey and soccer players was not surprising because of the aerobic nature of these sports that focuses on longer distance movement. Where these groups differed, however, was in power with soccer having more power despite a lower 1-RM back squat as a result of the mechanical aspects of soccer. When comparing the correlations between

the exercises, it was interesting to note that vertical jump and standing long jump were correlated, but neither was correlated with 1-RM back squat despite them all being lower body measures. This study is limited by its lack of height or body weight measurements which does not allow for the data to be expressed in relative terms.

3. "Strength and Biomechanical Risk Factors for Noncontact ACL Injury in Elite Female Footballers: A Prospective Study"

Source: https://mural.maynoothuniversity.ie/id/eprint/17941/1/JH_strength.pdf

ACL injury occurs 3-6 more times in female soccer players than males. This study was conducted to see if preseason testing of female soccer players was associated with noncontact ACL injuries. The metrics calculated in pre-season included isometric hip adductor and abductor strength, eccentric knee flexor strength, countermovement jump (CMJ) kinetics, single-leg hop kinematics, and demographic and injury history information. Prior ACL injury, a lower isometric hip adductor to abductor strength ratio, greater CMJ peak take-off force, and greater single-leg triple vertical hop average dynamic knee valgus, and ipsilateral trunk flexion were all independently associated with an increased risk of subsequent ACL injury. A model of CMJ peak take-off force, dynamic knee valgus, and ACL injury history classified ACL injury from no injury in female soccer players with 78% total accuracy. Between-leg asymmetry in lower limb strength and CMJ kinetics was seen as not associated with subsequent ACL injury risk. #1 identified risk factor of ACL injury is prior ACL injury. The preseason measures of hip strength, single-leg triple vertical hop frontal plane knee and trunk kinematics, and CMJ kinetics were independently associated with future noncontact ACL injury.

4. "Identifying ACL injury risk factors in female athletes using technology"

Source: https://valdperformance.com/news/identifying-acl-injury-risk-factors

ACL injuries occur 3-6 times more in girls than boys. ⅔ of female athletes never return to pre-injury peak performance. ACL injury is a noncontact injury during strong changes of direction, deceleration, or landing movements. Neuromuscular exercise programs reduce ACL injury rates by 45%. VALD's testing factors associated with non-contact ACL injury are lower hip adductor to abductor strength ratios, greater vertical hop dynamic knee valgus and ipsilateral trunk flexion angles, larger CMJ peak take-off forces, and previous ACL injury.

5. "Identification of potential risk factors for lower limb injuries in female team-sport athletes: a prospective cohort study"

Source: https://www.tandfonline.com/doi/full/10.1080/24733938.2023.2181386#d1e250

Female athletes tend to experience more acute ligament injuries and ACL injuries in comparison to men while male athletes experience more muscle and bone stress injuries in

comparison to women. Specifically, female athletes have more acute ligament injuries compared to male athletes as well as more ACL injuries in comparison to men. Female athletes also have a greater amount of time lost to injury and more season-ending injuries in comparison to men. Muscular strength is a potential influence in these differences as muscles stabilize joints and protect them from injury. Stress outside of sports has been shown to be associated with injury occurrence. This study considers 135 female athletes within the age range from 14 to 31 years old not following a lower body injury and collected data then followed injury history for the next 12 months. Abduction and adduction strength were measured using VALD performance equipment and principle components analysis was used to reduce the amount of variables. The results state that athletes with a family history of ACL injury were around 4 times more likely to experience an ACL injury. The injured group had a slightly higher asymmetry between legs in hip abductor and adductor strength compared to the uninjured group. In the principal components analysis PC1 consisted of mean adduction and abduction strength, PC2 consisted of adductor asymmetry and abductor asymmetry, PC3 consisted of the same as PC2 with different degree measurements. These principal components explained 65.48% of the variance. Final conclusion of this study is that weak hip adductor strength and larger asymmetries were correlated with a greater probability of injury.

6. "VALD NordBord: Hamstring Strength Testing"

Source: scienceforsport.com/vald-nordbord-hamstring-strength-testing/?srsltid=AfmBOoqNGzoXS3oTn3oAGwORJ_scS9PK-NdJCEbzqZrtsO5Gjqdb5CQo&

Background on the Nordbord. It is a hamstring test providing assessment of strength and asymmetry. It focuses on the metrics of force, torque, and impulse. Force helps with more rapid insights into muscle strength. Torque measures rotational strength. Impulse is the total work demonstrating the sustainability of force over time. Normative data exists across sports to provide additional context to the data.

7. "Normative Data in College Volleyball Athletes Using DXA"

Source: https://dexalytics.com/news/normative-data-college-volleyball-athletes-using-d/

Compared positional differences in body composition in female college volleyball players. No difference in % body fat across the positions, while for women's basketball, it was significantly different across the different positions. Womens volleyball players % body fat simialr to a womens basketball player that is a shooting guard. An interesting difference in body composition observed was the positional differences in bone mineral density. Positional differences in bone mineral density may be an effect of front row players' repeated impacts from

jumping for spiking and blocking. Positions with a higher potential risk of ACL and lower body injury.

8. "Normative Hamstrings and Quadriceps Isometric Strength Values and Hamstrings-Quadriceps Asymmetry in Healthy Collegiate Soccer and Basketball Players"

Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC11268924/

Soccer and basketball injuries are the majority located in the lower extremities, with basketball injury occurrence slightly leading over soccer. Additionally, profound imbalance in the hamstring-quadriceps (H/Q) ratio <60% has been reported to have a heightened risk of lower limb injuries, especially hamstrings and ACL injuries.

9. "Relative Energy Deficiency in Sport (REDs) and knee injuries: current concepts for female athletes"

Source: https://www.sciencedirect.com/science/article/pii/S2059775424000993

Relative Energy Deficiency in Sport (REDs) is a syndrome that decreases the available energy that an athlete receives, functionality of reproductive and menstrual function, or other health systems. This can have an impact on male or female athletes. This syndrome is caused by a low energy availability (LEA) which makes it difficult for the body to maintain its physiological functions. Problematic LEA refers to this low energy availability occurring for significant durations that can significantly impact sport performance as well as potentially increase the risk of injury. The "Female Athlete Triad" was the name of an original syndrome which covered LEA, menstrual dysfunction, as well as decreased bone density. On average female athletes consume around 30% less carbohydrates as a ratio of their body weight in comparison to male athletes. This syndrome has been shown to significantly impact distance runners as well as making bone fractures more common in all female athletes. There is evidence that supports the idea that this syndrome can be a significant risk factor for knee injuries and should be addressed. Female athletes are known to be at higher risk for ACL injury which is due to dynamic knee valgus, greater quad dominance in landing, and femoral intercondylar notches that are smaller in comparison to males. REDs exaggerate the difference in risk factors for knee injuries between male and female athletes, and that this could be driven by a desire for thinness in female athletes that is often pushed by coaches unnecessarily. A prospective study found that in high school female athletes there was a 3 times higher likelihood of chronic overuse injuries within the knee in those with physiological derangements than those that did not have these derangements.

Questions:

1. What is Value.Percentage variable in the VALD Dynamo datasets?
2. Which test types of CMJ, IBSQT, HJ, DJ, ISOT, IMTP, SJ, SHLDISOT, SHLDISOY, SHLDISOI, SQT, ABCMJ, SLJ, LAH, and ISOSQT from the forcedeck datasets should be considered for our research questions or should all be considered?

Kenzie's Questions

What is the impact of relative strength (power/force proportional to weight), years in sport, and age impact ACL injury risk?

If athletes have a dominant side (soccer, softball, etc) which are they more likely to injure? What training could be done to mitigate this risk?

Are there season phases (off-season, beginning, middle, or end) where injuries are more likely to occur? Do they happen in the beginning due to load demand increasing or more at the end due to accumulated load across the season?

Try and filter contact vs non-contact injuries (listed under "General Mechanism")

What insights could you draw from the information in source 2 as it may pertain to injury risk across sport types?