KINETISENSE SINGLE-LEG HOP FOR THE EVALUATION OF KNEE BIOMECHANICS

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Anterior Cruciate Ligament (ACL) injuries are one of the most well-known lower-body injuries and can be significant in nature, often requiring extensive rehabilitation. In some cases, an ACL injury can require surgical intervention if severe enough. There are different levels of an ACL injury ranging from a strain to a complete rupture with many variations between. The mechanism of injury (MOI) is complex and multifactorial between both extrinsic and intrinsic variables. ACL injuries do not just impact the sporting and athletic communities, but the workforce, youth, and the general population. Kinetisense has developed a detection system that is cost-effective, accurate, and portable, providing a valuable tool to baseline and assess the risk of ACL injury.

THE PROBLEM

ACL injuries are known as one of the most debilitating and expensive lower extremity injuries specifically in the athletic population [1]. In the United States alone, it is estimated that there are 200 000 ACL injuries per year, each averaging $17,000 to $25,000 [2, 3, 4]. Of those injuries, it has been shown that 70% of them occur from a non-contact mechanism [1, 3, 2]. One of the largest variances in ACL injury is whether the injury occurred as a contact or non-contact impact which does not have a consistent definition in research. Non-contact ACL injuries can be defined as the absence of body-to-body contact, the absence of a direct impact to the knee or a body-to-body contact without a direct impact on the knee [3]. The MOI of an ACL injury is multidimensional and complex with many variables for each individual that can contribute to the occurrence [5]. Research has shown that there are body position factors that contribute to an ACL injury. LaBella et. al. determined that there are five common contributing factors to an ACL injury, all occurring on the injury leg: 1. the hip is internally rotated, 2. the knee is close to full extension, 3. the foot is planted, 4. the body is decelerating allowing for the opportunity of valgus collapse at the knee, also referred to as dynamic knee valgus, 5. the center of mass is behind or away from

the base of support. Carlson et. al. also determined that factors such as decreased plantar flexion at the ankle, low knee flexion, and increased hip flexion define the provocative position, where it is more likely to contract a non-contact ACL injury. Aside from biomechanical identifiers of an ACL injury, there are various other factors that can play a role including age, gender, neuromuscular indicators, playing surface and even footwear [3, 6].

Outside of the biomechanical factors, age and gender are the most prevalent factors in identifying risk of ACL injury [7, 8, 9]. Females, specifically around the age of 16, are at a significantly higher risk of ACL injury than males due to neuromuscular, anatomical, and hormonal differences [10, 11, 4, 8, 12].

Neuromuscular sequencing differences between males and females contribute to women having a higher risk factor of ACL injury. In females, quadriceps activation during eccentric contraction is one of the largest differentiating factors, accompanied by muscle activation latencies and recruitment patterns [7]. Early contraction of the quadriceps is the first cause of anterior tibial translation, which is when the tibia moves anteriorly and the femur remains in place, causing increased stress on the ACL **[Hirst].** This ***indicates*** that females are quadriceps dominant, meaning that the anterior chain of the lower body activates before the posterior chain of the body. In this case, the quadriceps are used to stop anterior tibial translation instead of the posterior chain of the lower body [12]. Using the hamstrings complex in the posterior chain of the body has been researched to be more effective in stopping anterior tibial translation and giving more protection to the ACL [12].

In relation to ACL injury, it is well known that generally females have a higher risk of injury than males [8, 12]. There are many different avenues of research that stem from risk injury between males and females in accordance to ACL injury.

Q-angle and pelvic width are some of the largest anatomical differences between males and females. In relation to gender, females have a larger pelvic width than males which is linked to having a smaller Q-angle [12]. The Q-angle is formed by a line from the anterior superior iliac spine to the midline of the patella, and the midline of the patella to the tibial tubercle [12]. Q-angle has a direct relation to the quadriceps, controlling the muscle force vector in the frontal plane [13]. As Prentice et. al. found, the neuromuscular contribution of anterior chain dominance in females puts them in the higher risk category of ACL injury.

Taking these biomechanical and neurological factors into consideration, females exhibit greater knee valgus motion during athletic movements than men. Pairing this with the structural differences in the pelvis and Q-angle increases the risk of knee injury, due to an increase in incidence of dynamic knee valgus [3, 14, 15].

ANALYZING KNEE MECHANICS THROUGH THE SINGLE LEG HOP

Biomechanical analysis of the take off and landing mechanics of the single leg hop test provides valuable insight into kinetic chain sequencing of the body. The ability to stabilize the tibio-femoral joint and prevent an internal rotation of the knee joint (valgus collapse) in the transverse plane reduces tensile load on the ACL, MCL and the medial meniscus.

Analyzing jumping and landing mechanics gives valuable insight into the compensatory strategies of the individual in their activities of daily life, work related activities and sport. Assessing variables such as the maximum degree of valgus collapse, the rate of valgus collapse (deg/sec), jump force (Newtons), and hip flexion (degrees) allows for analysis of the susceptibility of injury of the knee.

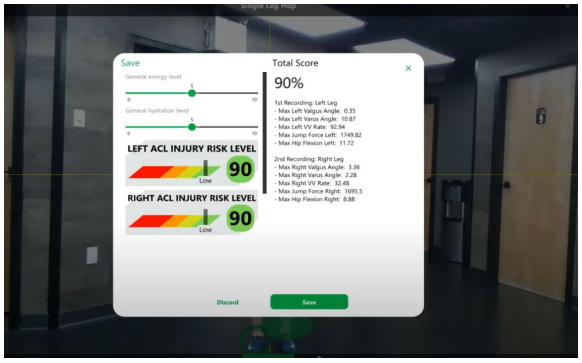

Figure 1.1. **Single Leg Hop Scoring Screen.** *Upon completing the Single Leg Hop, values will be provided for each leg. If the assessment has been completed correctly then the User will save the assessment.*

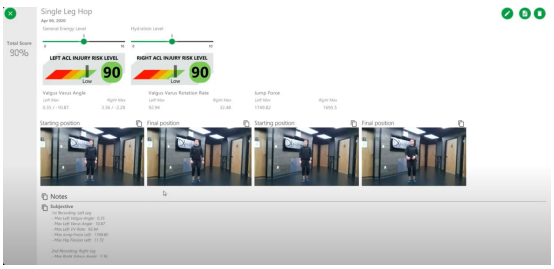

Figure 1.2. **Single Leg Hop Results Screen.** *Upon completing and saving a Single Leg Hop Assessment, the user is able to look back at the data and see a video of the movement and a breakdown of the scoring for each leg.*

THE SOLUTION

Kinetisense uses the Intel d415 sensor that has the capability to capture anywhere from 30 to 90 frames per second (fps) and is processed in real-time. This allows the system to accurately capture and measure quick, explosive movements.

Kinetisense has been designed to provide an affordable means of acquiring 3D joint tracking. The software itself provides real-time analysis and easy to understand reporting for motion capture. The real-time representation of human motion data and the increased inter and intra-examiner reliability in assessment separate Kinetisense from other movement analysis tools.

The 3D capture of joint and body-position replaces the need for wearable sensor technology that are both timely and difficult to place on the body. Wearable sensor placement presents issues in the inter-examiner and intra-examiner accuracy

and reproducibility in assessment as wearable sensors can shift in placement on the skin and anatomical landmarking is often subjective. Markerless motion capture allows for a high level of inter and intra examiner reliability.

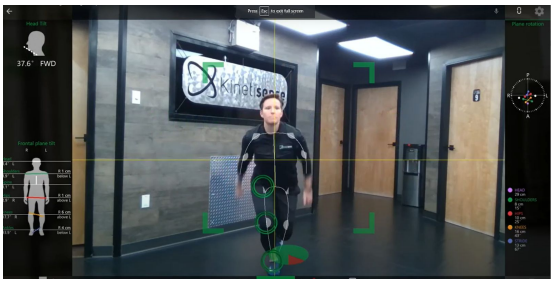

Figure 1.3. **Single Leg Hop Assessment Screen.** *In the Single Leg Hop Assessment screen, the user is able to see frontal and transverse plane information. The joints that are being assessed during the movement are highlighted with green circles.*

THE CONCLUSION

Overall in recent years there has been an increase in ACL injuries, specifically in the youth sporting population due to an increase in youth participation in organized sports, sport specialization at a younger age, and a higher diagnosis rate due to increased awareness [3]. LaBella, Hennrikus, and Hewett found that preventative training that targets plyometric and strength exercises while providing coaching on proper technique has been one of the most effective ways to prevent an ACL injury [1]. Pairing this with the Kinetisense Single-Leg Hop test to identify the base risk, and area of concern will allow practitioners to customize ACL prevention even more to an athlete's needs.

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