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ACL BRACING: IS IT STILL BEING DONE CLINICALLY AND DOES IT INFLUENCE CONFIDENCE AND/OR BIOMECHANICAL PERFORMANCE DURING A DROP VERTICAL JUMP?

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ABSTRACT

ACL BRACING: IS IT STILL BEING DONE CLINICALLY AND DOES IT INFLUENCE CONFIDENCE AND/OR BIOMECHANICAL PERFORMANCE DURING A DROP VERTICAL JUMP?

Introduction: Anterior cruciate ligament (ACL) ruptures account for 60% of sports-related injuries and the gold standard for treatment is surgical intervention to replace the damaged ligament to restore function of the ACL. Braces are typically used to return to previous physical activity levels; however, there are no clear guidelines on their utilization. Beyond the physical consequences of undergoing ACL reconstruction surgery, the psychological component is often ignored. **Purpose:** The aim of this study is to better understand the impact of knee bracing on both biomechanical factors and confidence following ACL reconstruction. Two aims comprise the overarching purpose; the first is to gather information about the overall experience with ACL reconstruction with regards to bracing. The second aim is to examine changes in confidence and physical performance of a drop vertical jump (DVJ) task between braced and unbraced conditions among those who have had recent ACL reconstruction. **Methods:** Survey data collected for Aim 1 included information on type of graft, bracing, time since surgery, and time in physical therapy. Participants completed a single testing session consisting of DVJ in braced and unbraced conditions with confidence surveys collected following each condition. Electromyography (EMG) and vertical ground reaction forces (VGRF) were collected during the testing sessions. Paired t-tests (normally distributed data) and Wilcoxon Sign Rank Tests (non-normally distributed data) were used to compare conditions (braced vs. unbraced). **Results:** For Aim 1, thirty-seven participants used a knee brace. Pain and physical impairments were commonly reported post- ACL reconstruction. In Aim 2, greater EMG activity of the biceps femoris was found in the braced condition, and greater reactive strength index by net impulse (RSI-NI) was found in the unbraced condition ($p < 0.05$). No changes in confidence were found

between braced and unbraced conditions. **Conclusion:** This study demonstrates a large portion of the ACL reconstruction population utilizes knee braces in return to sport and report pain as a common occurrence. The use of a knee brace may alter biomechanical performance. Confidence did not appear to be impacted by bracing vs. not bracing among individuals in our sample.

Key Words: ACL Reconstruction, Knee Brace, Biomechanical Performance, Confidence, Drop Vertical Jump

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Introduction

Tearing the anterior cruciate ligament (ACL) is a life-altering event and accounts for 60% of sports related injuries (Yapıcı et al., 2022). This type of injury requires surgery that puts the athlete on the sidelines anywhere from six to nine months (J. Wu et al., 2022). Following ACL reconstruction, return to sport is a major focus for athletes during the rehabilitation phase of recovery. However, only about 55% of athletes return to their sport at pre-injury levels following ACL reconstruction (Lentz et al., 2013).

As part of the rehabilitation process, some athletes are given braces and others are not; this has been a major point of contention among sports scientists, athletic trainers, orthopedic surgeons, and physical therapists (Greenberg et al., 2018), especially in recent literature. Braces are prescribed during the return to sport phase of recovery in an effort to provide stability and protect the graft (Lowe et al., 2017; Yang et al., 2019). Previous literature suggests that the majority of patients are not prescribed a brace for return to sport; however, Greenberg et al. (2018) indicated that 41% of physical therapists prefer brace usage for athletes who are returning to sporting activities. Several studies suggest no benefit or improvement in performance outcomes when a knee brace is worn (Goodstadt et al., 2013; Masini & Owens, 2013; Yang et al., 2019). One study went as far to say that with brace usage during return to sport, individuals should be advised they do not have a medical necessity and will experience a reduction in their performance if they wear a knee brace (Masini & Owens, 2013). On the contrary, several studies have found the utilization of a knee brace can positively affect performance outcomes (Dickerson et al., 2020; Hanzlíková et al., 2016).The lack of clear information and decision-making for knee bracing post ACL-reconstruction may cause hesitation, lack of trust, and fear of

re-injury that can contribute to an athlete's decision in whether they will play their sport again (Burland et al., 2018; Lentz et al., 2013).

No studies have examined the patient's perspective with their physical performance in relation to their knee brace being utilized. It is plausible that there is an emotional comfort of bracing that may help an athlete during recovery and return to sport. While the physical benefits are important, the potential for a mental "boost" during this traumatic time in an athlete's life is worthy of consideration.

The overarching goal of this thesis is to better understand the impact of knee bracing on both biomechanics and confidence of a physical performance task following ACL reconstruction. There are two aims for this project. The first is to gather information from participants who have had ACL reconstruction surgery on their overall experience following their initial injury with regards to bracing. We hypothesize that the majority of participants who have experienced an ACL surgery will have utilized a brace during their return to previous activity levels, and that patients will report fear and pain being common concerns during recovery. Participants from the first aim will be used to recruit participants from the Western Kentucky University student population to complete the second aim of this project.

The second aim is to examine changes in confidence and physical performance of a drop vertical jump (DVJ) task between braced and unbraced conditions. Confidence will be obtained by surveying participants with a combination of questions from the Tampa Scale of Kinesiophobia (TSK), International Knee Documentation Committee (IKDC) Subjective Knee Form 2000, and the ACL- Return to Sport after Injury (ACL-RSI) questionnaires following both braced and unbraced conditions. Physical performance will be assessed by analyzing vertical ground reaction forces (VRGF) and surface electromyography (EMG) of lower limb musculature

on the affected leg with and without the usage of a knee brace. We hypothesize that participants will report more confidence in braced vs. unbraced conditions, and the VGRF produced and EMG activity will be higher in the braced condition.

Literature Review

Injuries to knee ligaments, specifically the anterior cruciate ligament (ACL), can have catastrophic repercussions for athletes of any skill level (Mahapatra et al., 2018). Returning to sport is a major focus for recreational to elite athletes. ACL reconstruction following ACL injury is the standard treatment for those looking to return to pre-injury level sport (Mahapatra et al., 2018). Surgically repairing the knee is essential for rebuilding proper knee stability (J. Wu et al., 2022), but does not always guarantee that the athlete will return at a preinjury level. In fact, only 65% of athletes who undergo ACL reconstruction returned to some level of their sport while those who came back to a competitive level only made up about 55% (Webster & Feller, 2019). The ACL injury impacts the individual as a whole. Aspects that are affected in the aftermath of the injury include physical, psychological, emotional, and social well-being (Karlström et al., 2022). With the prevalence of ACL injuries and standard care being surgical treatment, one would think more than 65% of athletes undergoing surgery would return to sport. There is a gap between being functionally ready and psychologically ready to return. It is important to view all aspects of the injury and the individual. Closing the current gap that exists will result in more athletes returning to the sport they love. The following literature review will break down ACL function and rehabilitation, return to sport criteria, functional bracing, and psychological factors contributing to return to sport. There is an abundance of literature on these topics as separate entities, but few studies are looking at the relationship of functional braces and psychological factors from the individual's perspective.

ACL Function and Rehabilitation

The function of the ACL is to prevent forward movement of the tibia on the femur to create a stable structure. The ACL receives 86% of the total force counteracting that movement. There is also a proprioceptive function of the ACL since it has mechanoreceptors and free nerve endings (Markatos et al., 2013), showing just how important this structure is to a healthy knee. Injury to the ligaments of the knee can disrupt the functionality of the joint. The purpose of ACL reconstruction is to re-establish the function of the ACL (Markatos et al., 2013). Following surgery, intensive rehabilitation takes an average of six to nine months (J. Wu et al., 2022). Strength, power, and endurance are objectives during rehabilitation, and all three aspects are important in clearance for return to sport (J. Wu et al., 2022). After rehabilitation, the affected leg should be at least 90% as strong compared to that of the non-affected leg (Bühl et al., 2023; Gokeler et al., 2022; Markatos et al., 2013). Regaining function of the ACL means athletes should have more confidence in their knee. However, the literature supports that athletes have reported the opposite outcome.

There is an elevated risk of a second ACL injury in the first 2 years following ACL reconstruction, nearly one-third of athletes who return to sport experience a re-injury to their ACL (Johnson et al., 2020). Fear of re-tearing attributed to the individuals being less active following their first injury were reported within this group (Paterno et al., 2018). Success of the graft is dependent on the type of graft used, placement and motion of the tunnels to attach the graft, tension and fixation of the graft to the bone, and healing after surgery (Markatos et al., 2013). In a study examining the rates of graft failures, 25 of 782 individuals resulted in failure. 80% of the 25 were not using a brace when they returned to sport. It is important to note that only 30% of the 782 individuals were advised to brace with return to sport. The study concluded that although confidence was increased with the brace, the return to sport happened at an

improper time when the graft was not fully healed (Wright et al., 2019). With all the factors that contribute to clearance in return to sport, it is hard to pinpoint what exactly causes re-injury. There is a lack of literature following increased confidence with the brace. However, there are mixed feelings about whether to use the brace following reconstruction.

Return to Sport

Return to sport denotes returning to preinjury level performance at the same intensity, frequency, and quality as prior to the injury. Return to sport should be granted by a healthcare provider but should encompass the patient's perspective (Meredith et al., 2020). The decision to return to sport is a personal decision that an individual must determine. There are many factors that play a role in the decision to return to sport. Not only does the individual need to be ready physically but they need to be ready psychologically too. One year following ACL reconstruction 40% of individuals who did not return to sport (Lentz et al., 2013) reported experiencing pain, stiffness, weakness, and instability in their knee (Karlström et al., 2022). Fear of re-injury is another factor that has been reported and has led people to be less active following surgery (Ardern et al., 2014; Paterno et al., 2018; Webster et al., 2018). Healthcare provider's clearance is not the end all be all in return to sport. It is important for the individual to evaluate how they feel regarding their surgery and rehabilitation prior to making the decision to proceed with returning to sport.

Functionality of Braces in ACL Reconstruction

The use of knee braces in return to sport has been debated with no clear guidelines on when brace usage is appropriate following return to sport after ACL reconstruction (Lowe et al.,

2017). Braces are designed to provide stability to the knee and to protect the graft (Yang et al., 2019). It is important to protect the graft without surrendering overall function, range of motion, and proprioception (Lowe et al., 2017). We see the use of bracing throughout rehabilitation, from the moment the individual is out of surgery to the return to sport phase. Bracing immediately following surgery is meant to limit strain on the freshly corrected ACL and help rehabilitate gait in the early postoperative stages (Masini & Owens, 2013), while bracing during return to sport is meant to keep the knee stable, as discussed previously. Selecting a brace during return to sport should include cost effectiveness, comfort, and the level of activity of the patient (Lowe et al., 2017).

A study conducted in 2019 found that in 85% of ACL reconstruction cases, a brace was used during the return to sport phase. The study found that the use of braces after ACL reconstruction does not support the outcomes related to function or stability (Yang et al., 2019), suggesting that bracing may not be necessary. Similar conclusions were found in another study where individuals were tested three months following clearance for return to sport. Agility and vertical jump performance increased regardless of whether the brace was worn, concluding brace usage does not affect functional performance (Dickerson et al., 2020). In another study performed in 2013, 64 individuals were tested one year post ACL reconstruction. These participants underwent a battery of physical testing with and without the use of the brace. The study found that only 2 individuals performed better with the brace versus without the brace. Based on the results of this study, the surgically repaired knee was equal to the level of the unaffected knee. The strength, confidence, and control all matched the non-operative leg. This study concluded that recommendations should include a cessation to brace usage as it can become an impediment to performance (Goodstadt et al., 2013). All three studies concluded

bracing was not necessary in return to sport and alluded to performance increasing the further the individual got away from their ACL reconstruction date. The literature supports that physical function and performance improvements are associated with time.

The use of braces will remain a debate as long as there are worries regarding graft strength and its capacity to resist the stress that it undergoes during high level sport (Goodstadt et al., 2013). A systematic review found no patterns in the protective use of a brace during return to sport and concluded overall skepticism in brace usage (Marois et al., 2021). In a survey of physical therapists obtained from the APTA Academy of Orthopedic Physical Therapy and American Academy of Sports Physical Therapy via emails to their members, 41.1% preferred the use of functional braces in return to sport (Greenberg et al., 2018). In recent research, bracing was shown to not have an effect on the physical or psychological performance of individuals following ACL reconstruction (Gunadham & Woratanarat, 2024). Despite the literature not supporting use of functional braces following ACL reconstruction, physical therapists are reporting the use of braces in rehabilitation, specifically the return to sport phase. The patient's perspective in relation to the brace was not requested in the surveys.

However, another study published in 2016 found that braces can influence control of the operative knee while performing functional movements. The brace decreased internal rotation and knee valgus when performing step down, single leg drop jump, and pivoting turn and jump (Hanzlíková et al., 2016). Three years later, 15 individuals were studied during the same movements of the previous study. Those individuals communicated the movements were easier with the brace on rather than off (Hanzlíková et al., 2019). Both studies found that a brace can be used without any major implications to performance. There are conflicting views when it comes to the use of braces. Individuals who participate in higher level athletics can use braces to their

advantage. We know that returning to preinjury level is difficult, but using a brace to do so may have implications greater than the functional use of the brace (Bodendorfer et al., 2013), suggesting that braces could provide a psychological benefit (Masini & Owens, 2013). Few studies have found a psychological link to brace usage during return to sport. It is possible that healthcare providers are advising individuals to not wear braces due to lack of medical necessity and reduced performance while wearing the brace (Masini & Owens, 2013). A gap exists in whether individuals feel more comfortable with the brace and what they are being advised by their doctors. Although lack of medical need may exist for some, the brace could provide emotional reassurance for others. The prescription of braces is up to the healthcare provider's discretion, but the use of the brace may need to be the decision of the individual.

Psychological Factors Contributing to Return to Sport

Readiness to return to sport is influenced by the individual's psychological state (Ashton et al., 2020). The psychological effects that take place after ACL reconstruction have as much of an impact as the physical effects and mental health plays a part in our overall health (Meredith et al., 2020). Including psychological factors and "cognitive behavioral factors" such as self-efficacy, fear, and confidence should be included in the programming for return to sport following ACL reconstruction (Hart et al., 2024). A qualitative study performed in 2018 found that individuals who had undergone ACL reconstruction felt a sense of hesitation and did not trust their operative knee when involved in sport (Burland et al., 2018; Werner et al., 2018). In the early phases of return to sport, physical impairment can cause deficits in functional performance. In later stages of return to sport, psychological factors are likely the cause of any remaining deficits in individuals who have reported anxiety and fear in relation to re-injury. The

psychological cause has been related to pain. Individuals tend to avoid painful stimuli, therefore reducing performance when put in uncomfortable situations (Lentz et al., 2015). Opting out of activities that could produce ACL re-injury is another mechanism of fear in returning to sport. Lowering the intensity at which individuals used to play at has helped individuals avoid foolish situations that could result in injury (Heijne et al., 2022), while still being able to participate in sporting activities. Based on a study published in 2014, eleven of thirty-one participants returned to their pre-injury levels of sport, however they still reported they were fearful of undergoing a second ACL injury. These feelings were especially strong during the initial return to sport phase of rehabilitation (Tjong et al., 2014).

Being told that the operative knee won't be the same following ACL reconstruction can create a hesitancy toward movement. Hesitancy in lateral and forward movements were seen in individuals who had not returned to sport and were also associated with a lower degree of quality of life related to their knee while the individuals who returned to sport experienced more pain (Werner et al., 2018). Individuals who do not return to sport report constant knee symptoms, pain mainly, for their reasoning (Flanigan et al., 2013). When individuals are told, their knee won't be the same as it was previously, that can create a major psychological block. This block can produce the hesitancy seen in the study performed by Werner et al (2018).

It is plausible that there can be a disconnect between physical and psychological readiness to return to sport. A study performed in 2021 used a custom questionnaire, along with the ACL-Return to Sport after Injury (ACL-RSI) questionnaire and the International Knee Documentation Committee (IKDC) Subjective Knee Form 2000; to measure an individual's psychological level to return to sport. The study found that physical testing did not anticipate return to sport but the psychological testing did. The individuals who passed all return to sport

guidelines, including psychological readiness, did not sustain a second knee injury (Faleide et al., 2021). Younger aged males had a shorter return to sport period compared to females. Males had a better psychological outlook on the injury, had more limb symmetry, and higher knee scores when compared to females. However, both groups displayed anxiety toward the possibility of re-injuring their ACL (Webster et al., 2018). Studying psychological factors can provide a comprehensive view of the participant's decision to return to sport. Clearing patients for return to sport based solely on their physical characteristics causes dissatisfactory performance during tests such as strength, neuromuscular control, and dynamic movement (Burland, Toonstra, et al., 2019). Individuals' evaluation of their own preparedness and risk for return to sport may be the most central factor prompting their decision (Ardern et al., 2014). The mental state prior to surgery and early in the recovery stages is a major predictor in return to sport rates for those who undergo ACL reconstruction (Ardern et al., 2013). The number of months spent in rehabilitation can have negative impacts on that mental state. Individuals who view the injury as a devastating life event rather than a minor setback are less likely to go back to their sport.

In a qualitative study performed in 2014, individuals reported depression, pain, and their surgeon's recommendation for reasons why they did not return to sport. Regardless of satisfactory function of the knee, individuals tend to change their priorities to non-sport treated aspects (Tjong et al., 2014). The literature supports the shift in lifestyle of those who did not return to focus on other parts of their lives. Lack of confidence and fear of re-injury were also reported reasons why individuals did not return to sport. Mental health is important to the overall health of athletes and should not be overlooked when deciding when return to sport is appropriate (Meredith et al., 2020). Psychological factors play just as an important role in the individual's life as the physical factors when it comes to rehabilitation from ACL injury.

In summary, bracing is used in return to sport to protect the graft and limit undesired movement of the tibia. Some studies have found that the brace can be used without hindrance in performance while other studies have found that the brace can have a negative impact on performance. Psychologically, many studies have found fear and anxiety in relation to re-injury as the most common factor in individuals not returning to sport. Again, there has been little connection in psychological dependency on the brace during return to sport. The literature on bracing after ACL reconstruction and psychological factors is mixed and this is also reflected in clinical practice. There is no clear consensus on bracing vs. not bracing post ACL reconstruction, and it seems so many times, the athlete's perspective is not fully considered. Further research needs to investigate this connection to better understand how athletes can return to high level sports.

Methods

Participants

All study procedures were approved by the Western Kentucky University Institutional Review Board (IRB ID 24-005). In the first aim of this project, an email survey was distributed to the student population of Western Kentucky University (WKU) and through social media (Facebook). Email surveys were created and distributed via Qualtrics. Sixty-nine participants with a history of ACL injury and subsequent reconstruction surgery were recruited from WKU and the surrounding area. Participants, aged 18-29 years, indicated that they had a single ACL injury followed by a reconstruction surgery and used a knee brace when returning to their pre-injury levels.

Questions on the survey included type of ACL graft during surgery, time since surgery, time spent under physical therapist supervision, and type of knee brace used during return to previous physical activity levels (Appendix A). The survey was also used to identify whether participants had returned to previous physical activity levels, if the knee brace is still used, the type of activities the brace is for, and whether they have participated in collegiate athletics. Demographic data was collected, including zip code in which the surgery took place. Participants who wished to continue participation in Aim 2 provided their contact information.

To be included in the study for Aim 1, participants must have experienced an ACL injury that required subsequent reconstruction surgery. The Aim 1 survey ended for participants who experienced more than one ACL reconstruction and for those who did not utilize a knee brace during their return to the previous activity levels. However, their survey answers up until the cessation of the survey were collected and utilized in Aim 1. For Aim 2, convenience sampling was used from the results of Aim1. To be included in Aim 2, participants (1) had to have

experienced their ACL injury and reconstruction within the last 5 years, (2) been cleared by a healthcare professional to return to previous level of activity, (3) be 18-29 years of age, and (4) used a knee brace for return to previous physical activity levels. Participants were excluded from the study if (1) they never received surgical reconstruction intervention for an ACL injury, (2) experienced more than one ACL injury and reconstruction, (3) experienced an ACL injury and reconstruction surgery more than 5 years ago, (4) received surgical intervention within the last 8 months and have not been cleared by their healthcare provider to return to their prior level of sport-related activities, (5) did not use a knee brace for return to sport, or (6) had any underlying health conditions that would prohibit physical activity.

Participants were contacted via email for further participation and were provided with an incentive of a $40.00 gift card following the completion of Aim 2. A total of six participants were included in Aim 2. A sample size of N=6 is similar to other biomechanics studies in the field (Gokeler et al., 2010; Németh et al., 1997; Wong & Ng, 2006).

Procedures

Procedures for Aim 2 were conducted in the biomechanics laboratory in Smith Stadium at WKU. Consent was obtained electronically prior to arrival. Upon arrival, the participant's height, weight, age, and time since surgery were collected.

For Aim 2, bipolar electrodes (Noraxon Dual Electrodes, silver/silver chloride) were placed on the rectus femoris (RF), vastus medialis (VMO), vastus lateralis (VLO), biceps femoris (BF), gastrocnemius lateralis (LGAS), and gastrocnemius medialis (MGAS) of the affected leg according to SENIAM guidelines. Before placing electrodes, the skin was shaved, if necessary, lightly abraded, and cleaned with an alcohol swab. Once all electrodes were placed,

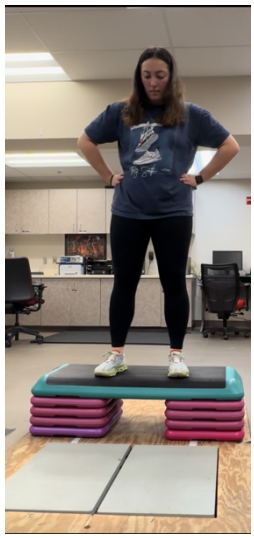
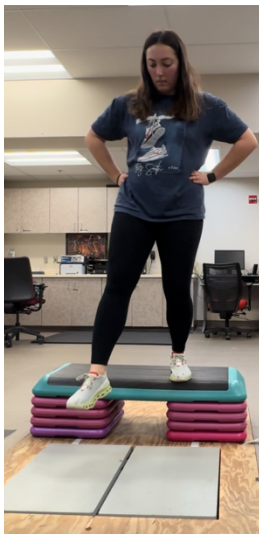
participants completed a five-minute warm-up on a Woodway W229 N591 curved treadmill at a self-selected walking pace (Beyer et al., 2020). Following the completion of the warmup period, the researcher placed the electrode transmitters on the leg of the participant and wrapped the transmitters and electrodes with a self-adhesive bandage to hold the equipment in place.

The drop vertical jump (DVJ) was used as it has been reported to be a good indicator of biomechanical ACL risk and has high inter-rater reliability (Beyer et al., 2020; Hewett et al., 2005). Previously, the DVJ tasks has been utilized to expose any deficits in performance in muscular strength and the voluntary activation patterns of the lower limb muscles (Saxby et al., 2023; Tayfur et al., 2021). Participants were instructed to perform a DVJ off a 31 cm platform constructed using multiple step platforms to reach the required height (Figure 1). The platform was placed behind the force plates so the participants were making a vertical movement (Bates et al., 2013). The researcher provided standardized instructions to stand with their hands on their hips and step off the platform with their dominant leg (Bradley et al., 2007; Kotsifaki et al., 2022; Ma et al., 2022). The dominant leg was identified as to which leg they felt comfortable kicking a soccer ball with (Morishige et al., 2019). Once the participant stepped off the platform, they landed on the force plates with one foot on each plate and jumped as high as possible, reaching both hands up in the air (Figure 1) (Bates et al., 2013; Morishige et al., 2019). Participants were instructed to keep contact time minimal and to jump as high and as quick as possible (Almonroeder et al., 2018; Hewett et al., 2005; Kuntze et al., 2021; Morishige et al., 2019; Torres-Banduc et al., 2021). Participants were instructed to stand on the force plates for at least two seconds following each trial to allow the software to complete data collection.

For familiarization, six total trial jumps were performed, three with the brace and three without the brace (Baumgart et al., 2017; Kuntze et al., 2021). Brace conditions were counter-

balanced in both the trial and testing jumps to avoid any testing order effects. A maximum of a two-minute rest break was utilized between the end of the trial jumps and starting the testing jumps. Testing jumps consisted of five jumps in both the braced (BR) and unbraced (UBR) conditions with a two-to-five-minute rest break between conditions.

Figure 1. DVJ Movement

A.  B.  C.  D. 

A. Participants stood atop the platform with hands on their hips. B. With their dominant leg, participants stepped off the platform with each foot landing on a force plate. C. Participants landed on both feet and immediately jumped to maximum height raising both hands into the air. D. Participants landed on both feet with both arms outstretched overhead.

Force plate data were collected to determine differences between conditions (Bates et al., 2013). Variables include jump height by flight time, jump height by net impulse, peak force, net impulse, maximum rate of force development (MRFD), contact time, reactive strength index by net impulse (RSI-NI), and total GRF (both force plates combined). Surface electromyography was used to collect peak muscle activation (uV) in the VMO, VLO, RF, BF, LG, and MG at a sampling rate of 2000 Hz. Table 1 defines each biomechanical variable. Biomechanics studies the kinetics and kinematics of the knee joint to better understand the function and stability of the knee joint (Georgoulis et al., 2010). These biomechanical variables are often used in the ACL

reconstructed population. All biomechanical data were collected and analyzed using Noraxon myoRESEARCH® 3 (MR3) software. Electromyography data was smoothed using root mean square to assess average activation.

Table 1. Biomechanical variable definitions

Biomechanical Variable	Definition
Peak EMG Activation	Measures maximum muscular activity during a movement (Hibbs et al., 2011)
Jump Height by Flight Time	Measures the jump height between the moment the feet leave the ground and the moment they land (BACA, 1999)
Jump Height by Net Impulse	Utilizes net impulse to calculate the jump height of the participant (Mizuguchi et al., 2012)
Peak Force	Maximal amount of force produced during a DVJ (Hsien-Te et al., 2019)
Net Impulse	Part of total impulse; causes the body to be projected into the air (Mizuguchi et al., 2012)
Max Rate of Force Development	Explosive strength voluntary muscular contractions (Maffiuletti et al., 2016)
Contact Time	Amount of time from when the foot contacts the force plates to the moment the foot leaves the plates (Santos-Concejero et al., 2013)
Reactive Strength Index by Net Impulse	Assesses jumping ability as a ratio of jump height by net impulse and contact time (Snyder et al., 2018)
Total Ground Reaction Force	The total force the ground exerts upward on the body (Clayton & Hobbs, 2019)

Participants then completed a survey to gather information regarding their self-reported confidence and performance for both conditions (Appendix B). Survey questions were adopted and modified from the 2000 International Knee Documentation Committee (IKDC) questionnaire, the ACL Return to Sport after Injury (ACL-RSI) questionnaire (Webster et al., 2018), and the Tampa Scale for Kinesiophobia (TSK) questionnaire (Ardern et al., 2014). Psychological readiness to return to sport was surveyed using questions from the ACL-RSI prior to participants leaving their testing session.

Statistical Analysis

All survey data were stored in Qualtrics. Standard content analysis was performed for the qualitative data collected from the surveys to identify underlying themes in qualitative data collected. For all other data, analyses were performed using SPSS Statistics software (Version 29, IBM Statistics, Armonk, NY). Normality of these data were assessed using Kolmogorov-Smirnov tests, as well as confirmed via visual inspection of histograms and Q-Q plots. A paired t-test was used to compare the data sets between the braced (BRD) and unbraced (UNB) conditions of the VGRF, EMG, and survey data collected during the in-person testing. A Wilcoxon test was used to compare non-parametric data. To indicate statistical significance, the alpha level (p-value) was set at 0.05.

Results

Aim 1

Within a seven-month period, survey responses were collected. Eighty-eight participants initiated the survey, 69 participants reported experiencing an ACL reconstruction surgery, but only 45 reported one ACL injury. Of those, 37 utilized a knee brace (Figure 2 and Figure 3). Of the 45 participants who reported only one ACL injury, two did not complete the survey. Of the remaining 43 participants, 20 reported experiencing their ACL injury over three years, 16 reported their ACL injury was one to three years ago, and seven reported having experienced their ACL injury within the last year (Figure 4). Graft types were collected from the remaining 42 participants who completed the survey. 50% of the respondents received a bone-patellar-tendon-bone graft (Figure 5).

Figure2. Flow chart of participants in Aim 1

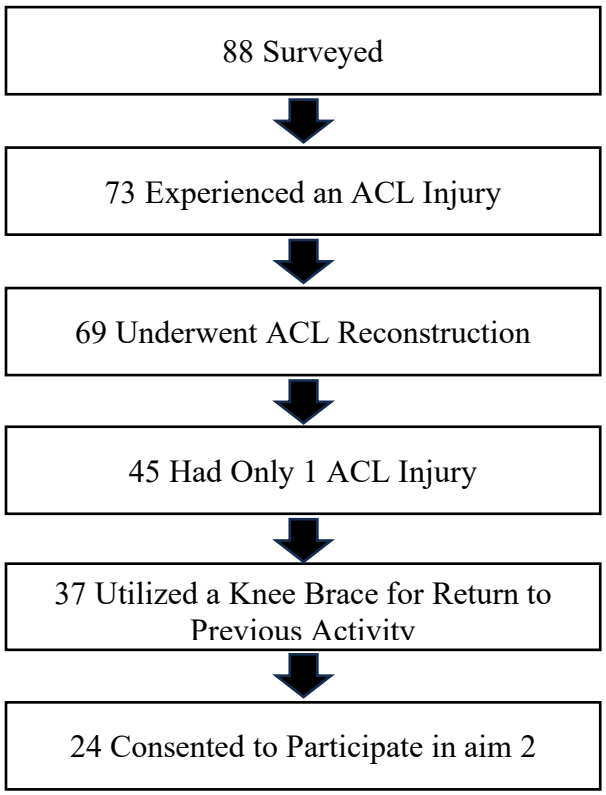


Figure 3. Number of ACL surgeries reported

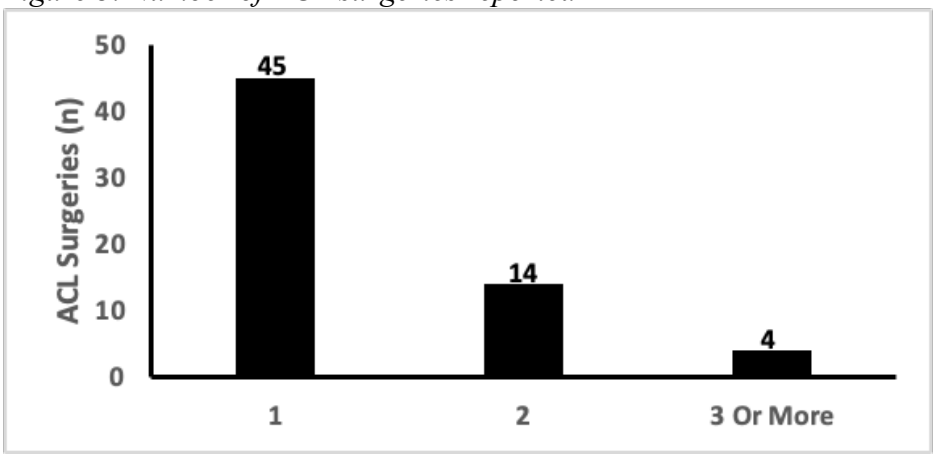


Figure 4. Time since surgery

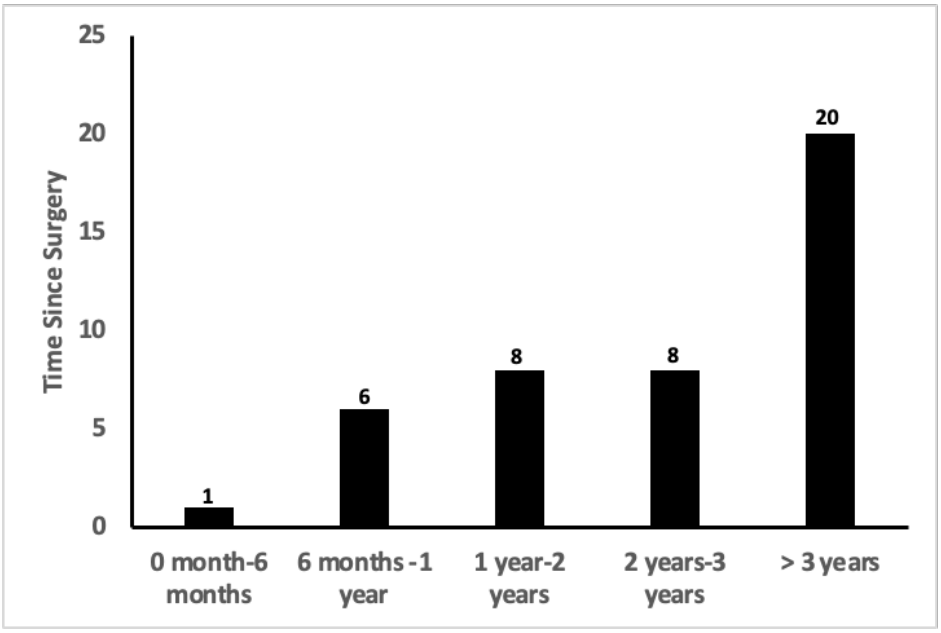
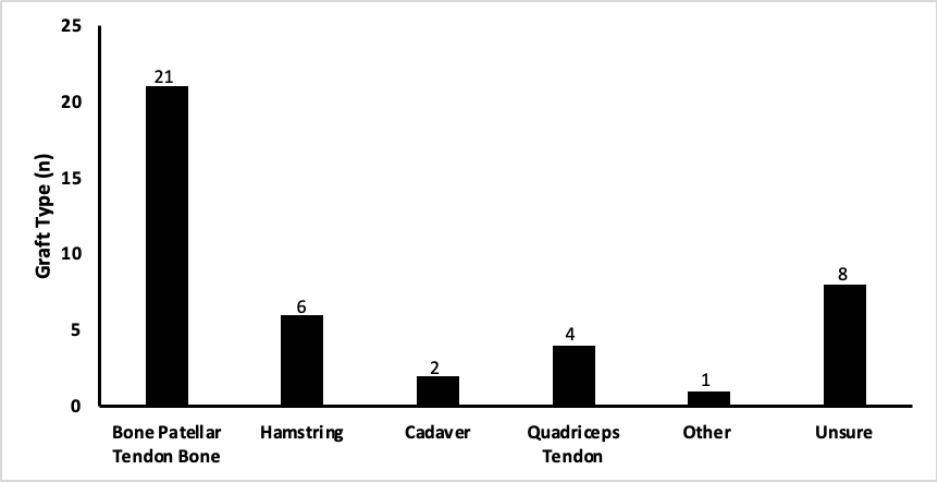


Figure 5. Type of ACL graft received



Rehabilitation time with a physical therapist was recorded, and 33 participants reported they spent four months to one year under the supervision of a physical therapist. Only four participants reported spending less than four months actively engaged in physical therapy and six reported spending more than one year in a rehabilitative setting with a physical therapist.

The majority of qualified respondents utilized a knee brace during their return to previous activity levels (Figure 6). Of those 37, 19 of those participants used a custom-fitted steel framed brace only, six used a combination of a custom-fitted steel framed brace and a soft knee sleeve, four only used a soft knee sleeve, and one only used the post-operative brace with no usage of a sports brace. Figure 7 depicts participants who have completely returned to pre-injury activity levels, somewhat returned, and those who have not returned to their pre-injury levels. Eighteen participants use their brace for any sporting activity that may include cutting and/or jumping, two participants use their brace for any activity they are partaking in, and 15 participants no longer use their brace. Of all the respondents, 77.1% were not collegiate athletes at any point in time. Table 2 lists the demographic data collected. Several participants did not complete the survey or

answer all the demographic questions, therefore the number of respondents (n) for each question are varied and reported in the table.

Figure 6. Brace usage during return to sport

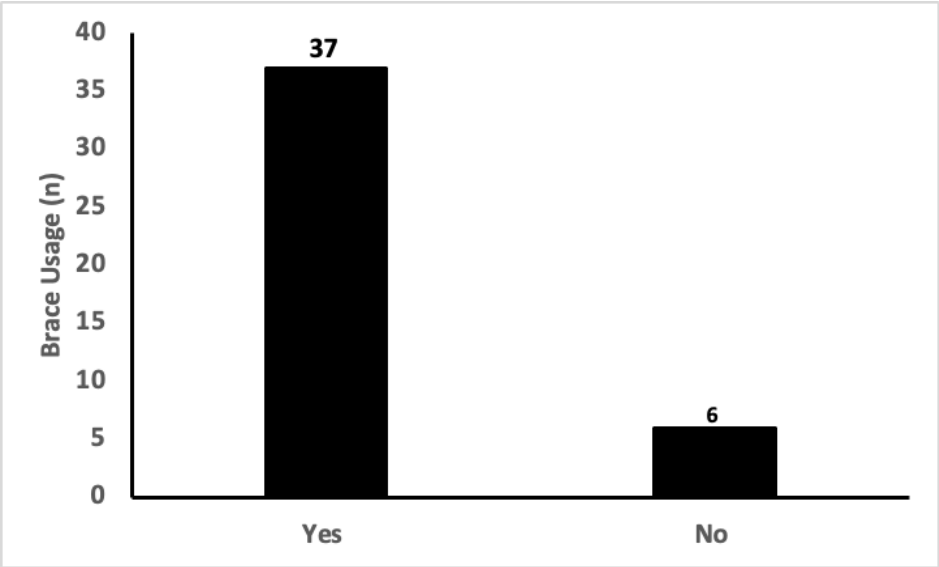


Figure 7. Participants who have returned to pre-injury levels

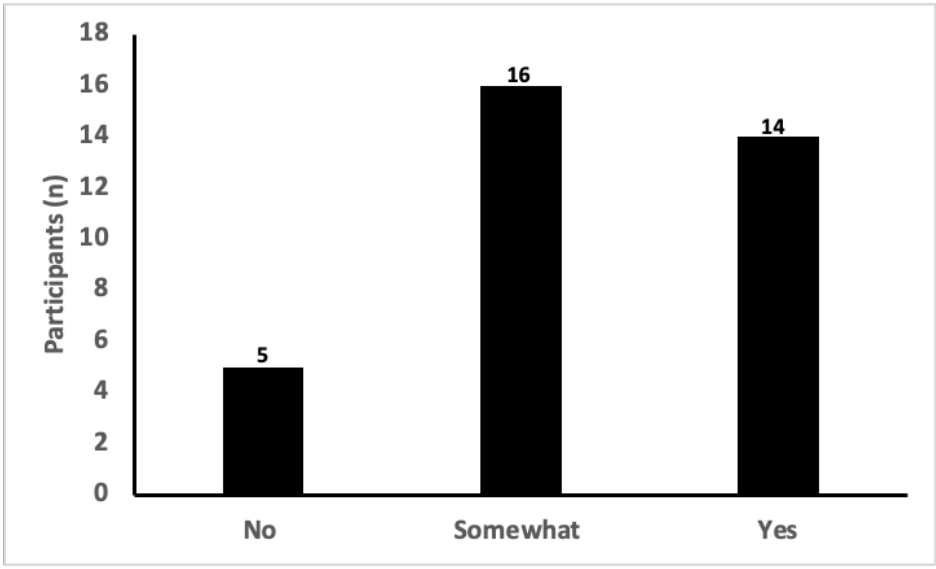


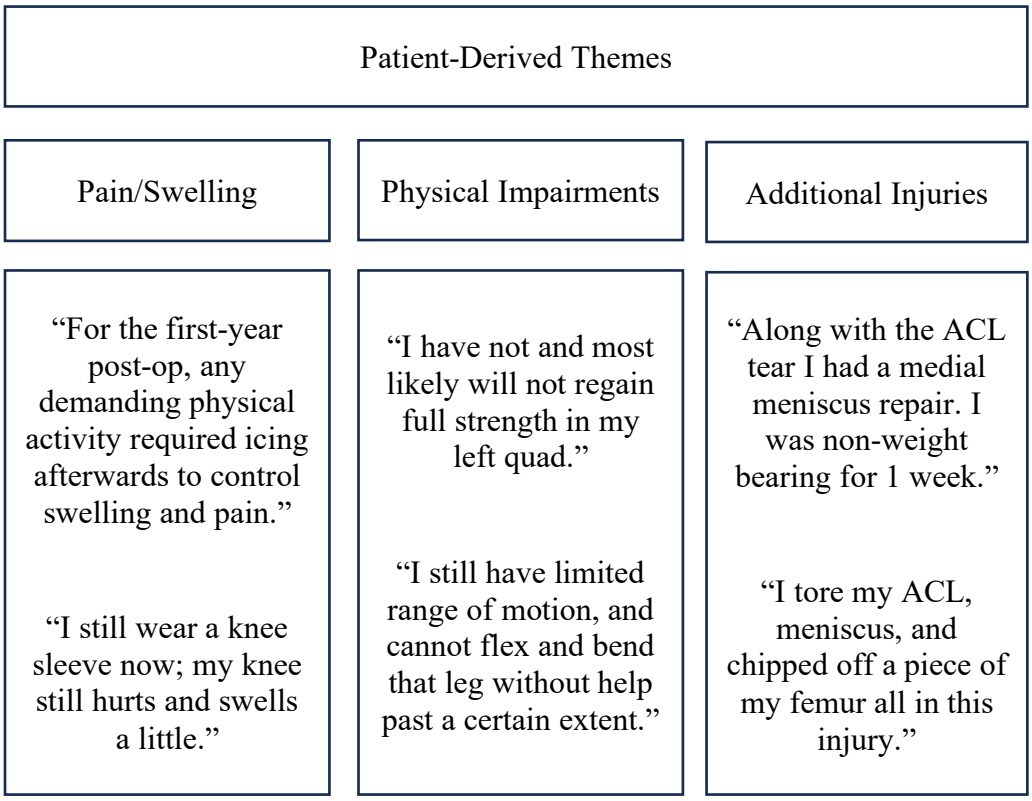
Table 2. Aim 1 Demographics

Characteristics	n (%)
Sex	**n=34**
Male	17 (50%)
Female	17 (50%)
Age (years)	**n= 31**
Mean Age	21.13 ± 3.43
Race	**n= 33**
Caucasian	26 (78.8%)
African American	4 (12.1%)
2 Or More Selected	3 (9.1%)

Participant-Derived Themes

Three underlying themes were identified from the participant surveys (Figure 8).

Figure 8. Underlying themes in Aim 1



Aim 2

Of the 24 participants that consented to contact in Aim 1, five were excluded due to their initial surgery taking place over five years ago. Nineteen participants were contacted for participation; six participants responded and were tested (Figure 9). Table 3 depicts the demographics of the Aim 2 participants.

Figure 9. Aim 2 participant flow chart

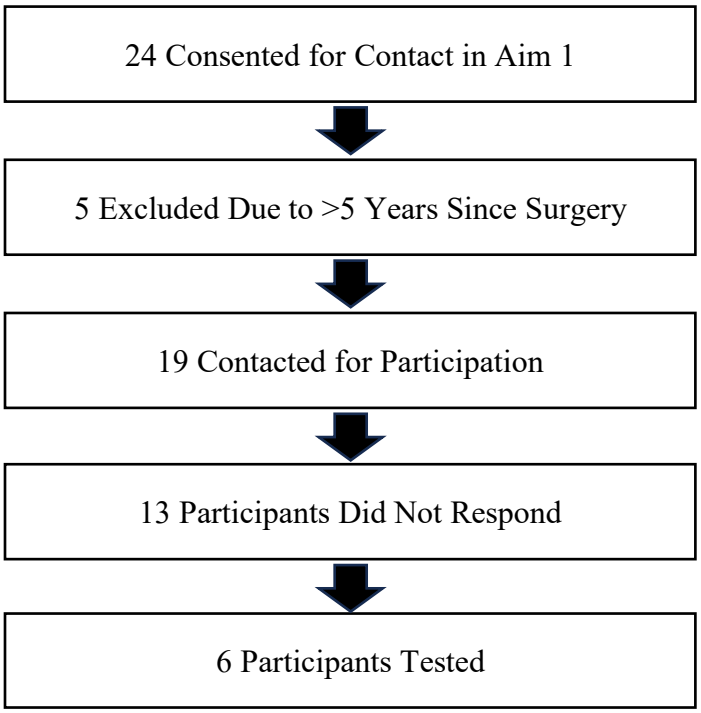


Table 3. Aim 2 Demographics

Participant	Age (years)	Gender	BMI	Surgery Side	Brace Type
1	21	Female	23.97	Left	Custom Fitted Steel Frame
2	19	Female	22.37	Right	Neoprene Sleeve
3	29	Male	28.52	Left	Custom Fitted Steel Frame
4	18	Female	24.24	Left	Custom Fitted Steel Frame
5	19	Female	19.31	Left	Custom Fitted Steel Frame
6	20	Female	26.44	Right	Custom Fitted Steel Frame

Electromyography

Table 4 lists peak muscle EMG values in the braced vs. unbraced conditions. One participant's EMG data were excluded due to a knee sleeve being worn, which was too tight to get around the EMG sensors and interfered with the signal. The EMG data were analyzed with

the five remaining participants. Peak EMG activation of the biceps femoris was significantly greater in the braced condition compared to the unbraced condition (p= 0.039).

Table 4. Average peak EMG activity

	Braced Peak EMG	Unbraced Peak EMG	p value
Vastus Medialis	257.56 ± 104.502	279.6 ± 68.448	0.507
Vastus Lateralis	255.76 ± 83.928	249.52 ± 111.271	0.839
Rectus Femoris	228.64 ± 74.804	320.08 ± 256.809	0.223
Biceps Femoris	139.096 ± 49.921	104.592 ± 43.687	0.039*
Lateral Gastrocnemius	173.752 ± 71.621	192.172 ± 86.705	0.543
Medial Gastrocnemius	269.44 ± 77.334	532.48 ± 668.916	0.686

* Indicates statistical significance

Vertical Ground Reaction Forces

Table 5 outlines the VGRF values in the braced vs. unbraced condition. A statistically significant difference was found in RSI-NI with the unbraced condition resulting in greater RSI-NI (p= 0.028).

Table 5. VGRF data

	Braced	Unbraced	p value
Jump height by flight time	22.4 ± 6.900	23.223 ± 6.980	0.116
Jump height by net impulse	29.923 ± 12.820	33.663 ± 14.728	0.067
Peak force	2037.367 ± 1024.790	1917.2 ± 775.341	0.173
Net impulse	178.267 ± 54.755	189.267 ± 54.377	0.095
MRFD	45756.133 ± 41278.847	35443.200 ± 19695.783	0.173
Contact time	0.572 ± 0.077	0.577 ± 0.112	0.834
RSI-NI	0.542 ± 0.274	0.626 ± 0.332	0.028*
Total GRF	1949.933 ± 823.780	2001.433 ± 900.924	0.345

* Indicates statistical significance

Confidence

No differences were reported in the in-person survey between braced and unbraced conditions following the DVJ movement. Of the six questions asked, each participant had the same level of confidence and stiffness both with and without the brace, with the exception of one participant who reported they could jump higher with the brace off. ACL-RSI score indicated varied levels of confidence among participants (Table 6). An increased ACL-RSI score suggests the participant has greater psychological confidence in their affected knee when participating in their sport (Table 7).

Table 6. In-person survey following both bracing conditions

Participant	1		2		3		4		5		6	
Condition	B	U	B	U	B	U	B	U	B	U	B	U
I was able to jump as high as I possibly could	A	A	A	A	A	A	*N	*A	A	A	A	A
I have no pain when performing this movement	A	A	A	A	A	A	A	A	A	A	A	A
I had to think about the movement before I performed it	D	D	A	A	A	A	A	A	A	A	D	D
My knee felt stiff by the end of the tests	D	D	D	D	D	D	D	D	D	D	D	D
I was hesitating to perform the jump after landing from the box	D	D	D	D	D	D	D	D	D	D	D	D
I had no fear in performing the movement	A	A	A	A	A	A	A	A	A	A	A	A

* Indicates different reported feelings
B- braced condition; U- unbraced condition; A- agree to the statement; N- neutral to the statement; D- disagree to the statement

Table 7. ACL-RSI scores

Participant	**ACL-RSI Score***
1	79.44
2	62.56
3	56.67
4	75.56
5	72.89
6	59.00

* ACL-RSI- Anterior Cruciate Ligament Return to Sport after Injury survey
A greater score indicates greater psychological confidence in playing their sport

Discussion

Aim 1 -To gather information from participants who have had ACL reconstruction surgery on their overall experience with their initial injury with regards to bracing. We hypothesized that the majority of participants will have utilized a knee brace during their return to previous activity levels and they will report fear and pain being common concerns during their recovery process.

Our study found that 86% of participants in Aim 1 utilized a knee brace when returning to their previous activity levels. Similarly, Yang et al. (2019) found that 85% of the ACL reconstruction cases they examined utilized a knee brace during their return to sport. The results of our study add to the contradicting literature on brace usage following ACL surgery. Xu et al. (2023) who found that only 50% of the members of the American Orthopedic Society for Sports Medicine (AOSSM) utilized a knee brace for their patients following ACL reconstruction. Goodstadt et al., (2013) tested participants who were one year post operation and found that their surgery leg was strong enough to discontinue the use of bracing. They found that further brace usage past this point, resulted in decreased performance. Interestingly, recent studies have identified the use of a knee brace following ACL reconstruction can result in re-injuries to the knee joint despite the purpose of bracing to prevent reinjury (MARS Group, 2019; Naik et al., 2019). Despite literature existing the support of not using a knee brace, previous research suggests that there is not enough evidence to support changes clinically or demonstrating that ACL bracing is cost effective for patients (Healy et al., 2018; Rodríguez-Merchán E. Carlos, 2016). Current knee bracing may be due to clinicians continuing to use dated procedures. Bracing has been utilized by so many clinicians over the years, it may be difficult to change this clinical norm, which does not appear to be supported by clinical evidence.

Pain was a patient-derived theme from Aim 1. This patient-reported theme is consistent with the literature on ACL recovery. A study performed in 2020 found that knee pain was related to knee extension deficits and the bone-patellar tendon-bone graft (BPTB). There was a 3.4 times higher incidence in knee pain in those who had a BPTB graft compared to those who had a hamstring graft (Marques et al., 2020). Pain has been reported to be a major factor for not returning to preinjury levels and has been demonstrated to be linked to psychological and physical readiness to return to preinjury levels (Betsch et al., 2021). The present study reported a greater occurrence of BPTB grafts compared to other graft types which could be attributed to the knee pain that was also reported. Several participants in our study reported they had experienced enhanced pain and swelling with any physical activity following their reconstructive surgery. One participant went on to state they had never resumed playing sports due to the pain that was a result of their injury.

Physical impairments, including limited range of motion (ROM), was another theme reported in Aim 1. One participant reported only spending a short time in physical therapy leading to continued deficits in ROM. Noll et al. (2015) found that deficits in the affected leg compared to the unaffected leg at four weeks post-operation led to continued deficits at twelve weeks post-operation. This lack of time in physical therapy described in our present study could have been attributed to the lack of ROM if full ROM was not achieved early in the post-operative phase. Feelings of never regaining full strength were also reported in the present study. Significant muscular deficits have been found during maximal strength tests nine to twelve months following ACL reconstruction (Larsen et al., 2015). Strength deficits seen at nine to twelve months post-surgery could be seen as an ongoing issue in those who are released from physical therapy too early in their rehabilitation. This could also be an issue in those who do not

continue strength training on their own following their release from physical therapy as regaining full quadriceps strength in the surgical leg takes longer than twelve months (Piussi et al., 2024).

Our hypothesis was partially supported with the majority of respondents utilizing a knee brace in their return to previous activity levels and pain was a commonly reported theme from the survey collection. However, fear was not a common underlying theme, but our initial survey did not ask any fear-based questions in the initial survey and respondents did not leave any comments referring to fear in the open-ended question section.

Aim 2 - To examine changes in confidence and physical performance during a jump task between braced and unbraced conditions. We hypothesized that confidence, EMG, and VGRF would be greater in the braced vs. unbraced conditions.

Confidence, EMG, and VGRF in both braced and unbraced conditions were assessed in Aim 2 of the study. Confidence was analyzed to determine if increased confidence would result in increased biomechanical outcomes. No differences in the surveys between braced and unbraced conditions, except for one participant, were found. One participant reported being able to jump higher in the unbraced condition compared to the braced condition while the other five participants reported zero changes between the conditions. Throughout the testing sessions, participants verbally reported a variety of continued issues with their affected knee. The one participant who reported being able to jump higher in the unbraced condition was the only participant who reported rarely wearing a knee brace during sporting activities. During their testing session, the remaining five participants noted varying issues they still have with their knee.

ACL-RSI scores were calculated after the testing sessions. The ACL-RSI was developed to determine how the psychological aspect affects returning to sport following ACL reconstruction (Webster et al., 2008). An increased ACL-RSI score indicates greater psychological confidence in the performance of the affected knee with 56 points reportedly correlated with low psychological confidence and 75 points correlated with high psychological confidence in the affected knee (J L Langford et al., 2009; Maffiuletti et al., 2016; Meierbachtol et al., 2018). A previous study found that the use of a knee brace resulted in greater knee confidence during hop tests and step downs as well as improvements in knee pain (Hart et al., 2016). However, in our study, there were no statistically significant differences found in confidence as reported by the surveys collected directly after the testing conditions or as reported by the ACL-RSI.

In the current study, participants increased peak biceps femoris activation in the braced condition during the DVJ task. Increased biceps femoris activation when a standardized knee brace was worn during a single leg drop landing was also previously noted (Chuang et al., 2015). The hamstrings have been found to compensate the action of the hip where there are deficits in the knee joint during a single leg DVJ, suggesting the hamstring may play a role as an agonist to the ACL in participants who are either ACL deficient or those who have had an ACL reconstruction (Kotsifaki et al., 2022). The hamstring may also be compensating for the quadriceps that are often weakened following ACL reconstruction surgery (Bertrand Sonnery-Cottet et al., 2019). A systematic review found that 70% of the studies they examined found modified EMG activity during a landing task, suggesting the affected limb will assume altered strategies during landing to resist the forces acting on the ACL (He et al., 2020). The findings of our study suggest that the use of the brace in the DVJ movement may lead to altered landing

strategies as a compensation mechanism. A landing strategy in which the hamstring becomes dominant may be utilized in the present study to favor the affected limb (Patras et al., 2012). Additionally, in those who reported having significant fear after ACL reconstruction had increased biceps femoris EMG activity that could be due to an altered landing strategy for increased stabilization and to protect the stability of the knee joint during single leg hop tests (Markström et al., 2022). The time period between injury and study participation (on average, 30 months in the present study) may be relevant in that the brace may not fit appropriately as it was likely sized for them within six months post-surgery. Atrophy of the quadricep muscle is often seen following ACL reconstruction and is associated to muscular strength (Thomas et al., 2016). If the muscles of the leg have gotten stronger, which is logical/likely, the brace may be inappropriately applying pressure to certain muscle groups and contributing to changes in EMG data. Additionally, five of the six participants had custom-fitted steel framed braces with soft straps on the back of the brace with the steel frame resting across the anterior surface of the thigh. The soft straps on the back of the brace could have no effect on the hamstrings, while the rigid frame of the front of the brace could potentially inhibit the quadriceps. However, with adding any type of wrap to the lower limb, brace or self-adhesive bandage utilized to secure the EMG sensors, we could potentially see the use of either affect the overall outcome of the study or interfere with the signal of the EMG sensors.

A significant difference was found in RSI-NI with greater RSI-NI being found in the unbraced condition. RSI has been shown to be reduced in the affected leg during continuous single leg hop tasks but previous studies have not compared RSI-NI in a braced vs unbraced condition during a DVJ movement (Hirohata et al., 2022; Read et al., 2023). The aforementioned studies examined participants who were less than one year post ACL surgery while our study

examined participants who were at least one year post surgery. Rehabilitation and increased confidence as time has passed could have contributed to the increased RSI-NI seen in our study. Reactive strength index has been found to be restored in participants with an average time since surgery of 27 months (Flanagan et al., 2008). Participants who are further from their initial surgery date may have regained the ability for their lower extremity muscles to rapidly produce force. The participants in our study, as mentioned previously, were on average, 30 months from their initial surgery date. However, accommodation strategies may be at play due to the influence of the brace vs. not wearing the brace.

Our hypotheses regarding Aim 2 were not wholistically supported, as the only variable that was higher in the braced condition was the EMG activity of the biceps femoris, and participants did not report changes in their confidence between the braced vs. unbraced conditions. Contrarily, RSI-NI was greater in the unbraced condition, compared to the braced condition. Similar to previous findings, physical performance in hop tests were greater in unbraced conditions, and quicker knee joint loading has been found in the cessation of brace usage compared to continued brace usage (Goodstadt et al., 2013; Rishiraj et al., 2024). Brace usage did not affect the overall biomechanical performance or confidence of participants during a DVJ movement.

We expected to see differences in peak force generation between braced and unbraced conditions, and we suspect we were not powered well enough to see these differences (i.e. small sample size). Using a Critical Value Approach, if we had observed the same paired difference with the same paired standard deviation [i.e. the same effect size] with twenty patients, we would have had a significant p-value of 0.048. Of note, only having nineteen patients with the same effect size would have given us a p-value of 0.054, so twenty participants are the number we

would have needed to detect significant differences in peak force between the two conditions. Future work should consider using a sample size of at least 20 for this outcome.

Confidence is a major player in the psychological readiness to return to sport (Hart et al., 2020). A wholistic approach should continue to be adopted by clinicians working with the ACL reconstructed population. Patients who have a negative outlook regarding their knee following their injury are likely to experience decreased performance outcomes (Hart et al., 2024). A recent systematic review found that reduced knee confidence existed three to ten years following ACL reconstruction (Hart et al., 2024). Immediately following surgery, emotional distress has been cited (Christino et al., 2015). If they psychological aspects are not dealt with during rehabilitation, we could expect to see continued psychological problems.

Following ACL reconstruction, changes in the neural pathways have been identified within this population (An, 2018; Burland, Lepley, et al., 2019; Grooms et al., 2017). Due to surgery, the mechanoreceptors in the lower limb are affected, in addition to pain and swelling that occur, cause a disruption in the afferent signaling pathways of the central nervous system (CNS) (Burland, Lepley, et al., 2019; Grooms et al., 2017). The associated changes in neuroplasticity modify the proprioceptive feedback from the musculature leading to altered muscular control (An, 2018). This neuroplasticity can be attributed to sensory feedback that has changed, as well as "behavioral motor control compensations" (Grooms et al., 2017). These can be caused by pain and compensations occurring in the affected limb (Grooms et al., 2017). When pain and compensation occur, fear is often associated with the movements leading to fear-avoidance (Burland, Lepley, et al., 2019). It is of human nature to avoid painful stimuli leading to not only physical but psychological reasons not to perform certain tasks or movements (Betsch et al., 2021). The use of a brace could alleviate some of the pain often associated with an ACL

injury (Dessery et al., 2014). It can be argued that due to the neuroplasticity that occurs in the ACL reconstructed population the usage of a knee brace following reconstruction can lead to a dependence on the brace. The brace can become a crutch to patients inhibiting the afferent pathways of the CNS when the brace is being worn. A brace has been shown to improve the proprioceptive feedback of the affected limb, but not because of the physical constraints of the brace (G. K. H. Wu et al., 2001). Whether or not the patient believes they are still injured or at risk or re-injury is a learned behavior following ACL reconstruction surgery. The psychological components could be largely contributed to altered neural pathways.

Limitations

Limitations of the present study include a small sample size from the student population at WKU. Although statistically significant outcomes in this study, combined with findings from other similar investigations, provide support for future work with a larger sample, it does not provide the best external validity to emulate the population outside the university. Our study was looking for a niche population with specific criteria which caused trouble in the recruiting process. This population is difficult to study due to variations in the injury itself, recovery, and rehabilitation. The protocol of a DVJ could have been intimidating to individuals in the population following the ACL reconstruction process and could have prevented them from wanting to participate in the current study due to fear avoidance. This study also took place in a controlled, laboratory setting, which may not fully represent normal sport-related or real-world movement patterns. In addition, even the unbraced condition still had sensors and a light self-adhesive wrap on it, which may have still influenced movement patterns and results. The use of the self-adhesive bandage could have altered the outcomes of the study since the affected leg still

had sensory feedback to the CNS even when the brace was not being worn. Previous research has identified the use of kinesiotaping to have positive outcomes during a drop vertical jump (Limroongreungrat & Boonkerd, 2019), suggesting that even in the unbraced condition, the affected leg was still "braced." Lastly, the protocol was not demanding enough to emulate fatiguing situations that participants may be engaging in outside of the laboratory setting. This is important because injuries tend to happen more under fatigued conditions due to changes in movement patterns (Cortes et al., 2014), oftentimes patterns that are less coordinated and efficient.

Future Directions

Future research should work to include a larger sample size of participants who have undergone an ACL reconstruction surgery and who have utilized a knee brace to identify whether there are differences in the braced vs. unbraced condition, and based on our effect sizes, at least 20 individuals should be included. Biomechanical factors that are closely related to self-reported confidence should be identified to further analyze whether there are differences in the affected limb with bracing. A protocol to induce muscular fatigue should be used to examine the difference between a braced and unbraced condition. Future research should also include measuring ROM and strength of the quadriceps femoris during testing sessions. Strength and ROM were common physical impairments found during Aim 1 and may be related to overall performance in the ACL reconstructed population. The current study did not include strength and ROM tests due to a lack of a clinician to gather accurate readings. Another future research direction could examine differences in athletes and "normal" college-aged individuals to identify if there are differences in confidence within each population. Taken together, the ultimate goal of this line of work is to influence clinical practice. While there may never be consensus on bracing,

it seems logical that it may provide necessary support early in recovery, but there should come a point where dependency on the brace could be problematic. Future work needs to better understand if bracing has any real benefit and if so, at what time point in the recovery process does the risk begin to outweigh any added benefit.

Conclusion

The overall purpose of the project was to identify what portion of the population utilized a knee brace following ACL reconstruction during return to previous activity levels while examining patient-reported confidence and biomechanical performance outcomes in a braced vs. unbraced condition. Most of the participants in Aim 1 utilized a knee brace during their return to previous activity levels and reported pain as a major underlying theme to their injury in Aim 1. EMG activity was found to be higher in the braced condition within the biceps femoris partially supporting our hypothesis that there would be higher EMG activity in the braced condition. However, VGRF and confidence were not higher in the braced condition, in fact, RSI-NI was found to be higher in an unbraced condition. Our study did not identify a psychological dependence of brace usage in relation to confidence and physical outcomes. Confidence is a major component when returning to your previous activity levels following an ACL reconstruction. As reported by one participant following the testing session, “having an ACL tear senior of high school has taught me that life doesn’t end when bad things happen. 90% of the injury was mental but if you keep a positive attitude, it’ll be easier.”

References

Almonroeder, T. G., Kernozek, T., Cobb, S., Slavens, B., Wang, J., & Huddleston, W. (2018). Cognitive Demands Influence Lower Extremity Mechanics During a Drop Vertical Jump Task in Female Athletes. *The Journal of Orthopaedic and Sports Physical Therapy*, *48*(5), 381–387. https://doi.org/10.2519/jospt.2018.7739

An, Y. W. (2018). Fear of reinjury matters after ACL injury. *International Journal of Applied Sports Science*, *30*(2), 149–159.

Ardern, C. L., Österberg, A., Tagesson, S., Gauffin, H., Webster, K. E., & Kvist, J. (2014). The impact of psychological readiness to return to sport and recreational activities after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine*, *48*(22), Article 22. https://doi.org/10.1136/bjsports-2014-093842

Ardern, C. L., Taylor, N. F., Feller, J. A., Whitehead, T. S., & Webster, K. E. (2013). Psychological Responses Matter in Returning to Preinjury Level of Sport After Anterior Cruciate Ligament Reconstruction Surgery. *The American Journal of Sports Medicine*, *41*(7), Article 7. https://doi.org/10.1177/0363546513489284

Ashton, M. L., Kraeutler, M. J., Brown, S. M., & Mulcahey, M. K. (2020). Psychological Readiness to Return to Sport Following Anterior Cruciate Ligament Reconstruction. *JBJS Reviews*, *8*(3), Article 3. WorldCat.org. https://doi.org/10.2106/JBJS.RVW.19.00110

BACA, A. (1999). A comparison of methods for analyzing drop jump performance. *Medicine & Science in Sports & Exercise*, *31*(3). https://journals.lww.com/acsm-msse/fulltext/1999/03000/a_comparison_of_methods_for_analyzing_drop_jump.13.aspx

Bates, N. A., Ford, K. R., Myer, G. D., & Hewett, T. E. (2013). Impact differences in ground reaction force and center of mass between the first and second landing phases of a drop vertical jump and their implications for injury risk assessment. *Journal of Biomechanics*, *46*(7), Article 7. https://doi.org/10.1016/j.jbiomech.2013.02.024

Baumgart, C., Hoppe, M. W., & Freiwald, J. (2017). Phase-Specific Ground Reaction Force Analyses of Bilateral and Unilateral Jumps in Patients With ACL Reconstruction. *Orthopaedic Journal of Sports Medicine*, *5*(6), Article 6. https://doi.org/10.1177/2325967117710912

Bertrand Sonnery-Cottet, Adnan Saithna, Benedicte Quelard, Matt Daggett, Amrut Borade, Hervé Ouanezar, Mathieu Thaunat, & William G Blakeney. (2019). Arthrogenic muscle inhibition after ACL reconstruction: A scoping review of the efficacy of interventions. *British Journal of Sports Medicine*, *53*(5), 289. https://doi.org/10.1136/bjsports-2017-098401

Betsch, M., Hoit, G., Dwyer, T., Whelan, D., Theodoropoulos, J., Ogilvie-Harris, D., & Chahal, J. (2021). Postoperative Pain Is Associated With Psychological and Physical Readiness to Return to Sports One-Year After Anterior Cruciate Ligament Reconstruction. *Arthroscopy, Sports Medicine, and Rehabilitation*, *3*(6), e1737–e1743. https://doi.org/10.1016/j.asmr.2021.08.001

Beyer, E. B., Hale, R. F., Hellem, A. R., Mumbleau, A. M., Schilaty, N. D., & Hewett, T. E. (2020). INTER AND INTRA-RATER RELIABILITY OF THE DROP VERTICAL JUMP (DVJ) ASSESSMENT. *International Journal of Sports Physical Therapy*, *15*(5), 770–775. https://doi.org/10.26603/ijspt20200770

Bodendorfer, B. M., Anoushiravani, A. A., Feeley, B. T., & Gallo, R. A. (2013). Anterior Cruciate Ligament Bracing: Evidence in Providing Stability and Preventing Injury or Graft Re-Rupture. *The Physician and Sportsmedicine*, *41*(3), Article 3. https://doi.org/10.3810/psm.2013.09.2020

Bradley, P. S., Olsen, P. D., & Portas, M. D. (2007). The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *Journal of Strength and Conditioning Research*, *21*(1), 223–226. https://doi.org/10.1519/00124278-200702000-00040

Bühl, L., Müller, S., Nüesch, C., Pagenstert, G., Mündermann, A., & Egloff, C. (2023). Functional leg performance 2 years after ACL surgery: A comparison between InternalBrace™-augmented repair versus reconstruction versus healthy controls. *Journal of Orthopaedics and Traumatology*, *24*(1), 52. https://doi.org/10.1186/s10195-023-00723-5

Burland, J. P., Lepley, A. S., Cormier, M., DiStefano, L. J., Arciero, R., & Lepley, L. K. (2019). Learned Helplessness After Anterior Cruciate Ligament Reconstruction: An Altered Neurocognitive State? *Sports Medicine*, *49*(5), 647–657. https://doi.org/10.1007/s40279-019-01054-4

Burland, J. P., Toonstra, J. L., & Howard, J. S. (2019). Psychosocial Barriers After Anterior Cruciate Ligament Reconstruction: A Clinical Review of Factors Influencing Postoperative Success. *Sports Health*, *11*(6), Article 6. https://doi.org/10.1177/1941738119869333

Burland, J. P., Toonstra, J., Werner, J. L., Mattacola, C. G., Howell, D. M., & Howard, J. S. (2018). Decision to Return to Sport After Anterior Cruciate Ligament Reconstruction,

Part I: A Qualitative Investigation of Psychosocial Factors. *Journal of Athletic Training*, *53*(5), Article 5. https://doi.org/10.4085/1062-6050-313-16

Christino, M. A., Fantry, A. J., & Vopat, B. G. (2015). Psychological Aspects of Recovery Following Anterior Cruciate Ligament Reconstruction. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons*, *23*(8). https://journals.lww.com/jaaos/fulltext/2015/08000/psychological_aspects_of_recovery_following.6.aspx

Chuang, M.-H., Lee, Y.-M., & Lee, H.-J. (2015). EFFECTS OF FUNCTIONAL KNEE BRACE ON LOWER EXTREMITY MUSCLE ACTIVATIONS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION. *33rd International Conference on Biomechanics in Sports*. file:///Users/baileywatson/Downloads/sarahclarke,+6393-19342-1-CE%20(1).pdf

Clayton, H. M., & Hobbs, S. J. (2019). Ground Reaction Forces: The Sine Qua Non of Legged Locomotion.. Journal of Equine Veterinary Science. *Journal of Equine Veterinary Science*, *76*, 25–35.

Cortes, N., Onate, J., & Morrison, S. (2014). Differential effects of fatigue on movement variability. *Gait & Posture*, *39*(3), 888–893. https://doi.org/10.1016/j.gaitpost.2013.11.020

Dessery, Y., Belzile, É. L., Turmel, S., & Corbeil, P. (2014). Comparison of three knee braces in the treatment of medial knee osteoarthritis. *The Knee*, *21*(6), 1107–1114. https://doi.org/10.1016/j.knee.2014.07.024

Dickerson, L. C. M., Peebles, A. T. P., Moskal, J. T. M., Miller, T. K. M., & Queen, R. M. P. (2020). Physical Performance Improves With Time and a Functional Knee Brace in

Athletes After ACL Reconstruction. *Orthopaedic Journal of Sports Medicine*, *8*(8), Article 8. WorldCat.org. https://doi.org/10.1177/2325967120944255

Faleide, A. G. H., Magnussen, L. H., Strand, T., Bogen, B. E., Moe-Nilssen, R., Mo, I. F., Vervaat, W., & Inderhaug, E. (2021). The Role of Psychological Readiness in Return to Sport Assessment After Anterior Cruciate Ligament Reconstruction. *The American Journal of Sports Medicine*, *49*(5), Article 5. WorldCat.org. https://doi.org/10.1177/0363546521991924

Flanagan, E. P., Galvin, L., & Harrison, A. J. (2008). Force Production and Reactive Strength Capabilities After Anterior Cruciate Ligament Reconstruction. *Journal of Athletic Training*, *43*(3), 249–257. https://doi.org/10.4085/1062-6050-43.3.249

Flanigan, D. C., Everhart, J. S., Pedroza, A., Smith, T., & Kaeding, C. C. (2013). Fear of reinjury (kinesiophobia) and persistent knee symptoms are common factors for lack of return to sport after anterior cruciate ligament reconstruction. *Arthroscopy : The Journal of Arthroscopic & Related Surgery : Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *29*(8), Article 8. WorldCat.org. https://doi.org/10.1016/j.arthro.2013.05.015

Georgoulis, A. D., Ristanis, S., Moraiti, C. O., Paschos, N., Zampeli, F., Xergia, S., Georgiou, S., Patras, K., Vasiliadis, H. S., & Mitsionis, G. (2010). ACL injury and reconstruction: Clinical related in vivo biomechanics. *Travaux de La Société Française d'Arthroscopie*, *96*(8, Supplement), S339–S348. https://doi.org/10.1016/j.rcot.2010.09.015

Gokeler, A., Dingenen, B., & Hewett, T. E. (2022). Rehabilitation and Return to Sport Testing After Anterior Cruciate Ligament Reconstruction: Where Are We in 2022? *Arthroscopy,*

Sports Medicine, and Rehabilitation, *4*(1), e77–e82. https://doi.org/10.1016/j.asmr.2021.10.025

Gokeler, A., Hof, A. L., Arnold, M. P., Dijkstra, P. U., Postema, K., & Otten, E. (2010). Abnormal landing strategies after ACL reconstruction. *Scandinavian Journal of Medicine & Science in Sports*, *20*(1), e12–e19. https://doi.org/10.1111/j.1600-0838.2008.00873.x

Goodstadt, N. M., Hunter-Giordano, A., Axe, M. J., & Snyder-Mackler, L. (2013). Functional testing to determine readiness to discontinue brace use, one year after acl reconstruction. *International Journal of Sports Physical Therapy*, *8*(2), Article 2. WorldCat.org.

Greenberg, E. M., Greenberg, E. T., Albaugh, J., Storey, E., & Ganley, T. J. (2018). Rehabilitation Practice Patterns Following Anterior Cruciate Ligament Reconstruction: A Survey of Physical Therapists. *Journal of Orthopaedic & Sports Physical Therapy*, *48*(10), Article 10. https://doi.org/10.2519/jospt.2018.8264

Grooms, D. R., Page, S. J., Nichols-Larsen, D. S., Chaudhari, A. M. W., White, S. E., & Onate, J. A. (2017). Neuroplasticity Associated With Anterior Cruciate Ligament Reconstruction. *Journal of Orthopaedic & Sports Physical Therapy*, *47*(3), 180–189. https://doi.org/10.2519/jospt.2017.7003

Gunadham, U., & Woratanarat, P. (2024). Effect of knee bracing on clinical outcomes following anterior cruciate ligament reconstruction: A prospective randomised controlled study. *Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology*, *36*, 18–23. https://doi.org/10.1016/j.asmart.2024.01.006

Hanzlíková, I., Richards, J., Hébert-Losier, K., & Smékal, D. (2019). The effect of proprioceptive knee bracing on knee stability after anterior cruciate ligament

reconstruction. *Gait & Posture*, *67*, 242–247. https://doi.org/10.1016/j.gaitpost.2018.10.026

Hanzlíková, I., Richards, J., Tomsa, M., Chohan, A., May, K., Smékal, D., & Selfe, J. (2016). The effect of proprioceptive knee bracing on knee stability during three different sport related movement tasks in healthy subjects and the implications to the management of Anterior Cruciate Ligament (ACL) injuries. *Gait & Posture*, *48*, 165–170. https://doi.org/10.1016/j.gaitpost.2016.05.011

Hart, H. F., Crossley, K. M., Ackland, D. C., Cowan, S. M., & Collins, N. J. (2016). Effects of an unloader knee brace on knee-related symptoms and function in people with post-traumatic knee osteoarthritis after anterior cruciate ligament reconstruction. *The Knee*, *23*(1), 85–90. https://doi.org/10.1016/j.knee.2015.05.006

Hart, H. F., Crossley, K. M., Culvenor, A. G., Khan, M. C. M., West, T. J., Kennedy, J. B., Couch, J. L., & Whittaker, J. L. (2024). Knee Confidence, Fear of Movement, and Psychological Readiness for Sport in Individuals With Knee Conditions: A Systematic Review and Meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy*, *54*(4), 234–247. https://doi.org/10.2519/jospt.2024.12070

Hart, H. F., Culvenor, A. G., Guermazi, A., & Crossley, K. M. (2020). Worse knee confidence, fear of movement, psychological readiness to return-to-sport and pain are associated with worse function after ACL reconstruction. *Physical Therapy in Sport*, *41*, 1–8. https://doi.org/10.1016/j.ptsp.2019.10.006

He, X., Leong, H. T., Lau, O. Y., Ong, M. T.-Y., & Yung, P. S.-H. (2020). Altered Neuromuscular Activity of the Lower-Extremities During Landing Tasks in Patients With Anterior Cruciate Ligament Reconstruction: A Systematic Review of Electromyographic

Studies. *Journal of Sport Rehabilitation*, *29*(8), 1194–1203. https://doi.org/10.1123/jsr.2019-0393

Healy, A., Farmer, S., Pandyan, A., & Chockalingam, N. (2018). A systematic review of randomised controlled trials assessing effectiveness of prosthetic and orthotic interventions. *PLOS ONE*, *13*(3), e0192094. https://doi.org/10.1371/journal.pone.0192094

Heijne, A., Silbernagel, K. G., & Lundberg, M. (2022). "I don't opt out of things because I think I will get a sore knee, but I don't expose myself to stupid risks either": Patients' experiences of a second ACL injury—An interview study. *Knee Surgery, Sports Traumatology, Arthroscopy*, *30*(7), Article 7. https://doi.org/10.1007/s00167-021-06762-x

Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S. J., Colosimo, A. J., McLean, S. G., van den Bogert, A. J., Paterno, M. V., & Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. *The American Journal of Sports Medicine*, *33*(4), 492–501. https://doi.org/10.1177/0363546504269591

Hibbs, A. E., Thompson, K. G., French, D. N., Hodgson, D., & Spears, I. R. (2011). Peak and average rectified EMG measures: Which method of data reduction should be used for assessing core training exercises? *Journal of Electromyography and Kinesiology*, *21*(1), 102–111. https://doi.org/10.1016/j.jelekin.2010.06.001

Hirohata, K., Aizawa, J., Ohmi, T., Ohji, S., Mitomo, S., Ohara, T., Koga, H., Yagishita, K., Jinno, T., & Okawa, A. (2022). Reactive strength index during single-limb vertical continuous jumps after anterior cruciate ligament reconstruction: Cross-sectional study.

BMC Sports Science, Medicine and Rehabilitation, *14*(1), 150. https://doi.org/10.1186/s13102-022-00542-x

Hsien-Te, P., Chen-Yi, S., Zong-Rong, C., I-Lin, W., & Chin-Yi, W. (2019). Differences Between Bimodal and Unimodal Force-time Curves During Countermovement Jump. *International Journal of Sports Medicine*, *40*(10), 663–669.

J L Langford, K E Webster, & J A Feller. (2009). A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine*, *43*(5), 377. https://doi.org/10.1136/bjsm.2007.044818

Johnson, J. L., Capin, J. J., Arundale, A. J. H., Zarzycki, R., Smith, A. H., & Snyder-Mackler, L. (2020). A Secondary Injury Prevention Program May Decrease Contralateral Anterior Cruciate Ligament Injuries in Female Athletes: 2-Year Injury Rates in the ACL-SPORTS Randomized Controlled Trial. *Journal of Orthopaedic & Sports Physical Therapy*, *50*(9), Article 9. https://doi.org/10.2519/jospt.2020.9407

Karlström, J., Wiklund, M., & Tengman, E. (2022). Disrupted knee—Disrupted me: A strenuous process of regaining balance in the aftermath of an anterior cruciate ligament injury. *Knee Surgery, Sports Traumatology, Arthroscopy*. https://doi.org/10.1186/s12891-022-05252-6

Kotsifaki, A., Van Rossom, S., Whiteley, R., Korakakis, V., Bahr, R., Sideris, V., & Jonkers, I. (2022). Single leg vertical jump performance identifies knee function deficits at return to sport after ACL reconstruction in male athletes. *British Journal of Sports Medicine*, *56*(9), 490–498. https://doi.org/10.1136/bjsports-2021-104692

Kuntze, G., Nettel-Aguirre, A., Lorenzen, K. N., Küpper, J., Ronsky, J. L., Whittaker, J. L., & Emery, C. A. (2021). Vertical Drop Jump Biomechanics of Patients With a 3- to 10-Year History of Youth Sport–Related Anterior Cruciate Ligament Reconstruction.

Orthopaedic Journal of Sports Medicine, *9*(12), Article 12. https://doi.org/10.1177/23259671211058105

Larsen, J. B., Farup, J., Lind, M., & Dalgas, U. (2015). Muscle strength and functional performance is markedly impaired at the recommended time point for sport return after anterior cruciate ligament reconstruction in recreational athletes. *Human Movement Science*, *39*, 73–87. https://doi.org/10.1016/j.humov.2014.10.008

Lentz, T. A., Zeppieri, G., George, S. Z., Tillman, S. M., Moser, M. W., Farmer, K. W., & Chmielewski, T. L. (2015). Comparison of Physical Impairment, Functional, and Psychosocial Measures Based on Fear of Reinjury/Lack of Confidence and Return-to-Sport Status After ACL Reconstruction. *The American Journal of Sports Medicine*, *43*(2), Article 2. https://doi.org/10.1177/0363546514559707

Lentz, T. A., Zeppieri, G. J., Tillman, S. M., Indelicato, P. A., Moser, M. W., George, S. Z., & Chmielewski, T. L. (2013). Return to preinjury sports participation following anterior cruciate ligament reconstruction: Contributions of demographic, knee impairment, and self-report measures. *Journal of Orthopaedics & Sports Physical Therapy*. https://doi.org/10.2519/jospt.2012.4077

Limroongreungrat, W., & Boonkerd, C. (2019). Immediate effect of ACL kinesio taping technique on knee joint biomechanics during a drop vertical jump: A randomized crossover controlled trial. *BMC Sports Science, Medicine and Rehabilitation*, *11*(1), 32. https://doi.org/10.1186/s13102-019-0144-6

Lowe, W. R., Warth, R. J., Davis, E. P., & Bailey, L. (2017). Functional Bracing After Anterior Cruciate Ligament Reconstruction: A Systematic Review. *The Journal of the American*

Academy of Orthopaedic Surgeons, *25*(3), Article 3. WorldCat.org. https://doi.org/10.5435/JAAOS-D-15-00710

Ma, B., Zhang, T.-T., Jia, Y.-D., Wang, H., Zhu, X.-Y., Zhang, W.-J., Li, X.-M., Liu, H.-B., & Xie, D. (2022). Characteristics of vertical drop jump to screen the anterior cruciate ligament injury. *European Review for Medical and Pharmacological Sciences*, *26*(20), 7395–7403. https://doi.org/10.26355/eurrev_202210_30008

Maffiuletti, N. A., Aagaard, P., Blazevich, A. J., Folland, J., Tillin, N., & Duchateau, J. (2016). Rate of force development: Physiological and methodological considerations. *European Journal of Applied Physiology*, *116*(6), 1091–1116. https://doi.org/10.1007/s00421-016-3346-6

Mahapatra, P., Horriat, S., & Anand, B. S. (2018). Anterior cruciate ligament repair – past, present and future. *Journal of Experimental Orthopaedics*. https://doi.org/10.1186/s40634-018-0136-6

Markatos, K., Kaseta, M. K., Lallos, S. N., Korres, D. S., & Efstathopoulos, N. (2013). The anatomy of the ACL and its importance in ACL reconstruction. *European Journal of Orthopaedic Surgery & Traumatology*, *23*(7), Article 7. https://doi.org/10.1007/s00590-012-1079-8

Markström, J. L., Grinberg, A., & Häger, C. K. (2022). Fear of Reinjury Following Anterior Cruciate Ligament Reconstruction Is Manifested in Muscle Activation Patterns of Single-Leg Side-Hop Landings. *Physical Therapy*, *102*(2), pzab218. https://doi.org/10.1093/ptj/pzab218

Marois, B., Tan, X. W., Pauyo, T., Dodin, P., Ballaz, L., & Nault, M.-L. (2021). Can a Knee Brace Prevent ACL Reinjury: A Systematic Review. *International Journal of*

Environmental Research and Public Health, *18*(14), Article 14. WorldCat.org. https://doi.org/10.3390/ijerph18147611

Marques, F. da S., Barbosa, P. H. B., Alves, P. R., Zelada, S., Nunes, R. P. da S., de Souza, M. R., Pedro, M. do A. C., Nunes, J. F., Alves, W. M., & de Campos, G. C. (2020). Anterior Knee Pain After Anterior Cruciate Ligament Reconstruction. *Orthopaedic Journal of Sports Medicine*, *8*(10), 2325967120961082. https://doi.org/10.1177/2325967120961082

MARS Group. (2019). Rehabilitation Predictors of Clinical Outcome Following Revision ACL Reconstruction in the MARS Cohort. *JBJS*, *101*(9). https://journals.lww.com/jbjsjournal/fulltext/2019/05010/rehabilitation_predictors_of_clinical_outcome.3.aspx

Masini, B. D., & Owens, B. D. (2013). Current Recommendations for Anterior Cruciate Ligament Bracing: When to Use. *The Physician and Sportsmedicine*, *41*(1), Article 1. https://doi.org/10.3810/psm.2013.02.1997

Meierbachtol, A., Yungtum, W., Paur, E., Bottoms, J., & Chmielewski, T. L. (2018). Psychological and Functional Readiness for Sport Following Advanced Group Training in Patients With Anterior Cruciate Ligament Reconstruction. *Journal of Orthopaedic & Sports Physical Therapy*, *48*(11), 864–872. https://doi.org/10.2519/jospt.2018.8041

Meredith, S. J., Rauer, T., Chmielewski, T. L., Fink, C., Diermeier, T., Rothrauff, B. B., Svantesson, E., Senorski, E. H., Hewett, T. E., Sherman, S. L., Lesniak, B. P., & Panther Symposium ACL Injury Return to Sport Consensus Group. (2020). Return to sport after anterior cruciate ligament injury: Panther Symposium ACL Injury Return to Sport Consensus Group. *Knee Surgery, Sports Traumatology, Arthroscopy*. https://doi.org/10.1007/s00167-020-06009-1

Mizuguchi, S., Stone, M. H., Sands, W. A., Lamont, H. S., & Wassinger, C. A. (2012). Net Impulse and Net Impulse Characteristics in Vertical Jumping. *Electronic Theses and Dissertations*, 1459. https://dc.etsu.edu/etd/1459

Morishige, Y., Harato, K., Kobayashi, S., Niki, Y., Matsumoto, M., Nakamura, M., & Nagura, T. (2019). Difference in leg asymmetry between female collegiate athletes and recreational athletes during drop vertical jump. *Journal of Orthopaedic Surgery and Research*, *14*(1), Article 1. https://doi.org/10.1186/s13018-019-1490-5

Naik, A. A., Das, B., & Kamat, Y. D. (2019). Avoid post operative bracing to reduce ACL rerupture rates. *European Journal of Orthopaedic Surgery & Traumatology*, *29*(8), 1743–1747. https://doi.org/10.1007/s00590-019-02521-4

Németh, G., Lamontagne, M., Kam San Tho, & Eriksson, E. (1997). Electromyographic Activity in Expert Downhill Skiers Using Functional Knee Braces After Anterior Cruciate Ligament Injuries. *The American Journal of Sports Medicine*, *25*(5), 635–641. https://doi.org/10.1177/036354659702500508

Paterno, M. V., Flynn, K., Thomas, S., & Schmitt, L. C. (2018). Self-Reported Fear Predicts Functional Performance and Second ACL Injury After ACL Reconstruction and Return to Sport: A Pilot Study. *Sports Health*, *10*(3), Article 3. https://doi.org/10.1177/1941738117745806

Patras, K., Zampeli, F., Ristanis, S., Tsepis, E., Ziogas, G., Stergiou, N., & Georgoulis, A. D. (2012). Hamstring-Dominant Strategy of the Bone–Patellar Tendon–Bone Graft Anterior Cruciate Ligament–Reconstructed Leg Versus Quadriceps-Dominant Strategy of the Contralateral Intact Leg During High-Intensity Exercise in Male Athletes. *Arthroscopy*, *28*(9), 1262–1270. https://doi.org/10.1016/j.arthro.2012.02.014

Piussi, R., Simonson, R., Zsidai, B., Grassi, A., Karlsson, J., Della Villa, F., Samuelsson, K., & Senorski, E. H. (2024). Better Safe Than Sorry? A Systematic Review with Meta-analysis on Time to Return to Sport After ACL Reconstruction as a Risk Factor for Second ACL Injury. *Journal of Orthopaedic & Sports Physical Therapy*, *54*(3), 161–175. https://doi.org/10.2519/jospt.2023.11977

Read, P. J., Davies, W. T., Bishop, C., McAuliffe, S., Wilson, M. G., & Turner, A. N. (2023). Residual Deficits in Reactive Strength After Anterior Cruciate Ligament Reconstruction in Soccer Players. *Journal of Athletic Training*, *58*(5), 423–429. https://doi.org/10.4085/0169-20

Rishiraj, N., Taunton, J. E., Lloyd-Smith, R., Regan, W., Niven, B., & Woollard, R. (2024). Functional knee brace use for 21 h leads to a longer duration to achieve peak vertical ground reaction forces and the removal of the brace after 17.5 h results in faster loading of the knee joint. *Knee Surgery, Sports Traumatology, Arthroscopy*, *n/a*(n/a). https://doi.org/10.1002/ksa.12135

Rodríguez-Merchán E. Carlos. (2016). Knee Bracing After Anterior Cruciate Ligament Reconstruction. *Orthopedics*, *39*(4), e602–e609. https://doi.org/10.3928/01477447-20160513-04

Santos-Concejero, J., Granados, C., Irazusta, J., Bidaurrazaga-Letona, I., Zabala-Lili, J., Tam, N., & Gil, S. (2013). Differences in ground contact time explain the less efficient running economy in North African runners. *Biology of Sport / Institute of Sport*, *30*, 181–187. https://doi.org/10.5604/20831862.1059170

Saxby, D. J., Catelli, D. S., Lloyd, D. G., & Sawacha, Z. (2023). Editorial: The role of biomechanics in anterior cruciate ligament injuries prevention. *Frontiers in Sports and Active Living*, *5*. https://www.frontiersin.org/articles/10.3389/fspor.2023.1134969

Snyder, B. W., Munford, S. N., Connaboy, C., Lamont, H. S., Davis, S. E., & Moir, G. L. (2018). Assessing Plyometric Ability during Vertical Jumps Performed by Adults and Adolescents. *Sports*, *6*(4). https://doi.org/10.3390/sports6040132

Tayfur, B., Charuphongsa, C., Morrissey, D., & Miller, S. C. (2021). Neuromuscular Function of the Knee Joint Following Knee Injuries: Does It Ever Get Back to Normal? A Systematic Review with Meta-Analyses. *Sports Medicine*, *51*(2), 321–338. https://doi.org/10.1007/s40279-020-01386-6

Thomas, A. C., Wojtys, E. M., Brandon, C., & Palmieri-Smith, R. M. (2016). Muscle atrophy contributes to quadriceps weakness after anterior cruciate ligament reconstruction. *Journal of Science and Medicine in Sport*, *19*(1), 7–11. https://doi.org/10.1016/j.jsams.2014.12.009

Tjong, V. K., Murnaghan, M. L., Nyhof-Young, J. M., & Ogilvie-Harris, D. J. (2014). A Qualitative Investigation of the Decision to Return to Sport After Anterior Cruciate Ligament Reconstruction: To Play or Not to Play. *The American Journal of Sports Medicine*, *42*(2), Article 2. https://doi.org/10.1177/0363546513508762

Torres-Banduc, M., Ramirez-Campillo, R., Andrade, D. C., Calleja-González, J., Nikolaidis, P. T., McMahon, J. J., & Comfort, P. (2021). Kinematic and Neuromuscular Measures of Intensity During Drop Jumps in Female Volleyball Players. *Frontiers in Psychology*, *12*. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.724070

Webster, K. E., & Feller, J. A. (2019). A research update on the state of play for return to sport after anterior cruciate ligament reconstruction. *Journal of Orthopaedics and Traumatology*. https://doi.org/10.1186/s10195-018-0516-9

Webster, K. E., Feller, J. A., & Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Physical Therapy in Sport*, *9*(1), 9–15. https://doi.org/10.1016/j.ptsp.2007.09.003

Webster, K. E., Nagelli, C. V., Hewett, T. E., & Feller, J. A. (2018). Factors Associated With Psychological Readiness to Return to Sport After Anterior Cruciate Ligament Reconstruction Surgery. *American Journal of Sports Medicine*. WorldCat.org. https://nls.ldls.org.uk/welcome.html?lsidyva32157c5

Werner, J. L., Burland, J. P., Mattacola, C. G., Toonstra, J., English, R. A., & Howard, J. S. (2018). Decision to Return to Sport Participation After Anterior Cruciate Ligament Reconstruction, Part II: Self-Reported and Functional Performance Outcomes. *Journal of Athletic Training*, *53*(5), Article 5. WorldCat.org. https://doi.org/10.4085/1062-6050-328-16

Wong, Y.-M., & Ng, G. Y. F. (2006). Surface electrode placement affects the EMG recordings of the quadriceps muscles. *Physical Therapy in Sport*, *7*(3), 122–127. https://doi.org/10.1016/j.ptsp.2006.03.006

Wright, R. W., Huston, L. J., Nwosu, S. K., Allen, C. R., Anderson, A. F., Cooper, D. E., DeBerardino, T. M., Dunn, W. R., Haas, A. K., Lantz, B. (Brick) A., Mann, B., Spindler, K. P., Stuart, M. J., Albright, J. P., Amendola, A. (Ned), Andrish, J. T., Annunziata, C. C., Arciero, R. A., Bach, B. R. J., … MARS Group. (2019). Rehabilitation Predictors of

Clinical Outcome Following Revision ACL Reconstruction in the MARS Cohort. *The Journal of Bone and Joint Surgery. American Volume*, *101*(9), Article 9. WorldCat.org. https://doi.org/10.2106/JBJS.18.00397

Wu, G. K. H., Ng, G. Y. F., & Mak, A. F. T. (2001). Effects of Knee Bracing on the Sensorimotor Function of Subjects with Anterior Cruciate Ligament Reconstruction. *The American Journal of Sports Medicine*, *29*(5), 641–645. https://doi.org/10.1177/03635465010290051801

Wu, J., Kator, J. L., Zarro, M., & Leong, N. L. (2022). Rehabilitation Principles to Consider for Anterior Cruciate Ligament Repair. *Sports Health*, *14*(3), Article 3. https://doi.org/10.1177/19417381211032949

Xu, S., Cheema, S. G., Tarakemeh, A., Randall, J., Bechtold, M., Mullen, S., Schroeppel, P., Mulcahey, M., & Vopat, B. G. (2023). Return to Sport After Primary Anterior Cruciate Ligament (ACL) Reconstruction: A Survey of The American Orthopaedic Society for Sports Medicine. *Kansas Journal of Medicine*, *16*(1), 105–109. https://doi.org/10.17161/kjm.vol16.18617

Yang, X., Feng, J., He, X., Wang, F., & Hu, Y. (2019). The effect of knee bracing on the knee function and stability following anterior cruciate ligament reconstruction: A systematic review and meta-analysis of randomized controlled trials. *Orthopaedics & Traumatology: Surgery & Research*, *105*(6), Article 6. https://doi.org/10.1016/j.otsr.2019.04.015

Yapıcı, F., Gür, V., Sari, I. F., Köksal, A., Yurten, H., Üçpunar, H., & Çamurcu, Y. (2022). Prescription of knee braces after anterior cruciate ligament reconstruction: Fact or fiction? *Turk J Phys Med Rehabil*, *68*(3), 355–363. https://doi.org/DOI: 10.5606/tftrd.2022.8906

Appendices

Appendix A. Initial Survey

Standard: Torn ACL (1 Question)
Branch: New Branch
If
If Have you torn your ACL? No Is Selected
EndSurvey:
Block: Surgery (1 Question)
Branch: New Branch
If
If Have you had ACL reconstruction surgery? No Is Selected
EndSurvey:
Standard: Informed Consent (0 Questions)
Standard: # of surgies (1 Question)
Branch: New Branch
If
If How many ACL surgeries have you had? Three or more Is Selected
EndSurvey:
Branch: New Branch
If
If How many ACL surgeries have you had? Two Is Selected
EndSurvey:
Standard: ACL questions (3 Questions)
Standard: Brace (1 Question)
Branch: New Branch
If
If Did you use a knee brace for return to your previous activity level? No Is Selected
EndSurvey:
Standard: Brace questions (5 Questions)
Standard: Demographics (4 Questions)
Standard: Other (3 Questions)

Block: Torn ACL
Q1 Have you torn your ACL?

o Yes

o No

Block: Surgery
Q2 Have you had ACL reconstruction surgery?

o Yes

o No

Q3 Informed Consent

Block: # of surgeries
Q4 How many ACL surgeries have you had?

o One

o Two

o Three or more

Block: ACL questions
Q5 How long has it been since your most recent ACL surgery?

o 0 months – 6 months

o 6 months 1 day – 1 year

o 1 year 1 day – 2 years

o 2 years 1 day – 3 years

o More than 3 years 1 day. Please explain

_____

Q6 What type of graft did you receive?

o Bone patellar tendon bone graft

o Hamstring graft

o Cadaver graft

o Quadriceps tendon graft

o Other

o Unsure

Q7 How long did you receive physical therapy under the care of a physical therapist for your ACL reconstruction surgery?

o Less than 4 months

o 4 months 1 day – 8 months

o 8 months 1 day – 1 year

o More than 1 year 1 day

o I did not receive any physical therapy

Block: Brace
Q8 Did you use a knee brace for return to your previous activity level?

o Yes

o No

Block: Brace questions
Q9 What type of brace have you used? (Example: custom fitted steel-framed choice, neoprene knee sleeve; feel free to include a link)

_____

Q10 Have you returned to your pre-injury level of activity?

o No

o Somewhat

o Yes

Q11 Do you still use your brace?
o Yes, always with activity

o Sometimes

o Not at all

Q12 What type of activities do you still use your brace for?

o All activities

o Any sport-like activities that require cutting or jumping

o I do not use my brace

Q13 Have you participated, current or past, in organized collegiate athletics? (Not Intramural or club level)

o Yes

o No

Block: Demographics
Q14
Q15 What gender do you identify with?

o Male

o Female

o Non-binary/third gender

o Prefer not to say

Q16 What racial category best describes you? Select all that apply.

□ American Indian or Alaskan Native

□ Asian Pacific Islander

□ Black or African American

□ Hispanic

□ White/Caucasian

□ Other, please specify

_____

Q17 What zip code did your surgery take place in?

_____

Block: Other
Q18 Please leave any other thoughts or comments you would like to share regarding your recovery and return to previous physical activity levels.

_____

Q19 Do we have your permission to contact you for a subsequent research study you are eligible for?

o Yes

o No

Q19 If you willing to be contacted to discuss your experience and be tested with and without your knee brace in a drop vertical jump, please leave your email below.

_____

Appendix B. Testing Survey (2nd and 3rd surveys)

Standard: Testing questions (2 Questions)
Branch: New Branch
If
If Which condition (brace on or brace off) did you just complete? Brace off Is Selected
EndSurvey:
Standard: Self-Rated Knee Questions (7 Questions)

Start of Block: Testing questions

Q1 Please rate how you feel after completing the testing protocol.

	Disagree (1)	Neutral (2)	Agree (3)
I was able to jump as high as I possibly could (1)	o	o	o
I have no pain when performing this movement (2)	o	o	o
I had to think about the movement before I performed it (4)	o	o	o
My knee felt stiff by the end of the tests (5)	o	o	o
I was hesitating to perform the jump after landing from the box (6)	o	o	o
I had no fear in performing the movement (7)	o	o	o

Page Break

Q2 Which condition (brace on or brace off) did you just complete?

- o Brace off (1)
- o Brace on (2)

End of Block: Testing questions

Start of Block: Self-Rated Knee Questions

Q3 Place a mark on the line, which best describes you in relation to the statements.
0 is no confidence, 100 is completely confident
0 10 20 30 40 50 60 70 80 90 100

Are you confident that you can perform at your previous level of sport participation? ()	
Do you think you are likely to re-injure your knee by participating in your sport? ()	
Are you nervous about playing your sport? ()	
Are you confident that your knee will not give way by playing your sport? ()	
Are you confident that you could play your sport without concern for your knee? ()	
Do you find it frustrating to have to consider your knee with respect to your sport? ()	
Are you fearful of re-injuring your knee by playing your sport? ()	
Are you afraid of accidentally injuring your knee by playing your sport? ()	
Do thoughts of having to go through surgery and rehabilitation prevent you from playing your sport? ()	
Are you confident about your ability to perform well at your sport? ()	
Do you feel relaxed about playing your sport? ()	

Q4 Please select an option based on how you feel to each statement.

	Strongly disagree (1)	Disagree (2)	Agree (3)	Strongly agree (4)
I'm afraid that I might injure myself if I exercise. (1)	o	o	o	o
My accident has put my body at risk for the rest of my life. (2)	o	o	o	o
I'm afraid that I might injure myself accidentally. (3)	o	o	o	o
Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening. (4)	o	o	o	o
I can't do all the things normal people do because its too easy for me to get injured. (5)	o	o	o	o

Q5 What is the highest level of activity you can participate in on a regular basis?

- o Very strenuous activities like jumping or pivoting as in basketball or soccer (1)
- o Strenuous activities like heavy physical work, skiing or tennis (2)
- o Moderate activities like moderate physical work, running, or jogging (3)
- o Light activities like walking, house work, or yard work (4)
- o Unable to perform any of the above activities due to knee pain (5)

Q6 What is the highest level of activity you can perform without significant swelling in your knee?

- o Very strenuous activities like jumping or pivoting as in basketball or soccer (1)
- o Strenuous activities like heavy physical work, skiing or tennis (2)
- o Moderate activities like moderate physical work, running, or jogging (3)
- o Light activities like walking, house work, or yard work (4)
- o Unable to perform any of the above activities due to knee pain (5)

Q7 Since your injury, how stiff or swollen is your knee?

- o Not at all (1)
- o Midly (2)
- o Moderately (3)
- o Very (4)
- o Extremely (5)

Q8 What is the highest level of activity you can perform without significant knee pain?

- o Very strenuous activities like jumping or pivoting as in basketball or soccer (1)
- o Strenuous activities like heavy physical work, skiing or tennis (2)
- o Moderate activities like moderate physical work, running, or jogging (3)
- o Light activities like walking, house work, or yard work (4)
- o Unable to perform any of the above activities due to knee pain (5)

Q9 Please leave any other thoughts or comments you would like to share, regarding your knee or surgery, that feel important to your "story".

End of Block: Self-Rated Knee Questions

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