Examination of Task-Specific Motor Confidence and Performance in Patients at 6-Months Post Anterior Cruciate Ligament Reconstruction

by

Brittany Bruinooge

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Rady Faculty of Health Sciences

University of Manitoba

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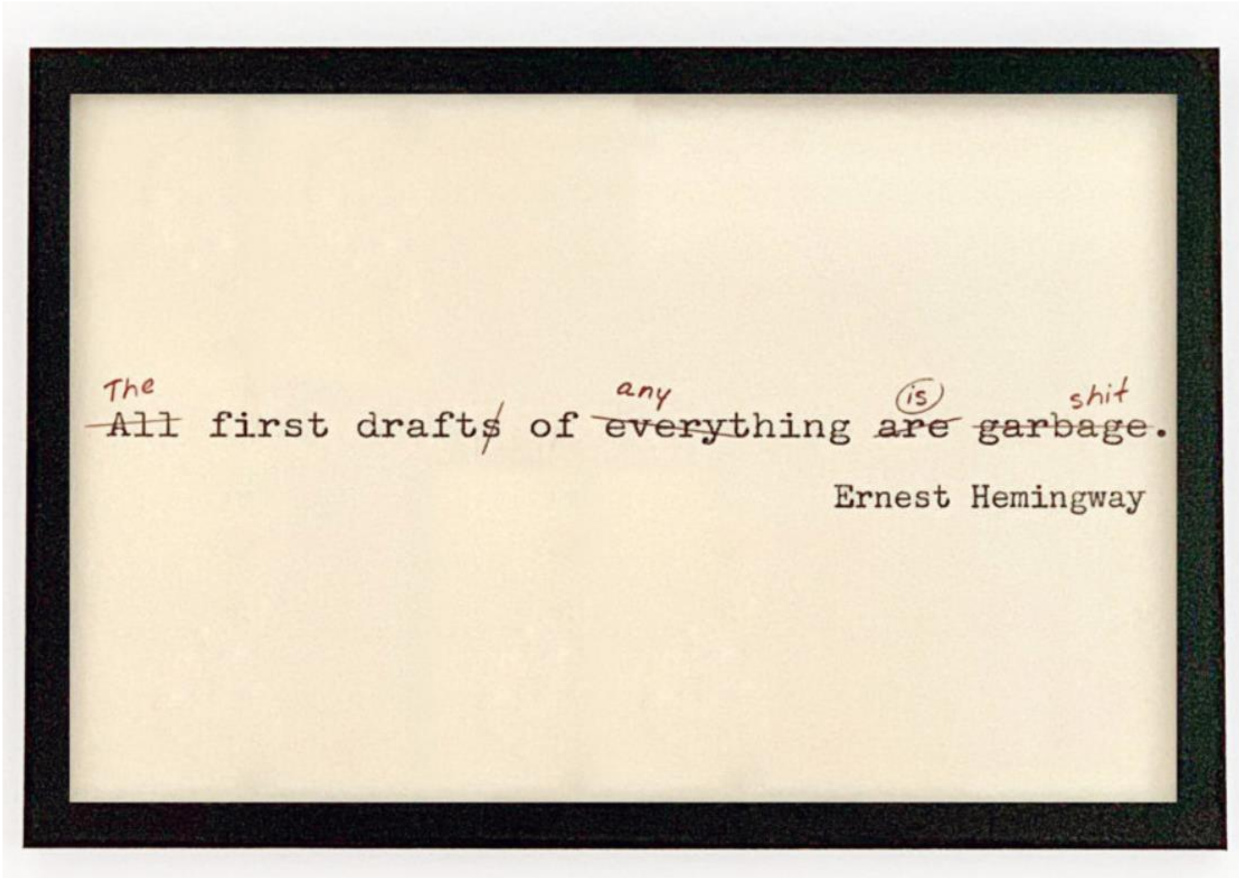
ABSTRACT

Return-to-sport (RTS) batteries that incorporate physical *and* psychological components optimize information collected to guide rehabilitation and better inform RTS decisions[1,2]. Measuring task-specific confidence in addition to psychological readiness may assist in identifying athletic skills requiring intervention to optimize one's readiness to RTS[3]. This study examined between-limb differences in confidence via self-reported and assessor-rated task-specific confidence, psychological readiness (Anterior Cruciate Ligament Return to Sport After Injury, ACL-RSI), and functional performance. 32 participants of varying graft types (82.4 ± 22.2 kg, 172.6 ± 8.3 cm, 25.6 ± 8.5 yrs., 20F:12M, ACL-RSI 50 ± 22%) were assessed at 6-months following ACL reconstruction (ACLR). Affected limb (A) performance for the SLH (A: 88.3 ± 41.4 cm, was reduced compared to the unaffected (UA) limb (UA: 117.7 ± 42.2 cm, $p<0.001$), and for the DVJ (A: 1.6 ± 0.6 $N \cdot kg^{-1}$, UA: 2.30 ± 0.59 $N \cdot kg^{-1}$, $p<0.001$), but COD times were marginally faster (A: 3.3 ± 0.5s, UA: 3.4 ± 0.5 s, $p=0.047$). Participant's confidence ratings were lower on the affected limb for the single leg hop (SLH) (A: median 6 (range 2-9), UA: 9 (6-10), $p<0.001$), the drop vertical jump (DVJ) (A: 6 (3-9), UA: 10 (6-10), $p<0.001$) and the change of direction task (COD) (A: 7 (2-10), UA: 9 (7-10), $p<0.001$). Absolute performance for the SLH ($\rho=0.558$, $p=0.001$) and COD ($\rho=-0.643$, $p<0.001$) were correlated with the ACL-RSI but not for the DVJ or when any measure was expressed as a symmetry index (LSI; SLH $r_s=0.167$, $p=0.360$; DVJ $r_s=-0.029$, $p=0.877$; COD $r_s=0.127$, $p=0.49$). Clinical relevance: It remains unclear if physical and psychological readiness are independent of each other or if one directly influences the other. In either case, a RTS battery that solely assesses physical function may not reflect the holistic recovery status of the patient. Assessing confidence when minimal

between-limb performance differences are present (i.e., COD) might provide additional information to help guide the decision-making process regarding RTS.

ACKNOWLEDGEMENTS



IYKYK.

Thank you to Dan and my committee for overseeing this jourrney with me. You truly have no idea how encourging your kind words during early morning talks, late night talks, weekend talks, <u>*all*</u> the talks helped me through this process! Thank you for working with me to complete this study, I have learnt a lot from all of you.

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ABBREVIATION GLOSSARY

ACL	Anterior cruciate ligament
ACLR	Anterior cruciate ligament reconstruction
ACL GC	Anterior cruciate ligament graft choice
ACL-RSI	Anterior cruciate ligament return to sport after injury
BPTB	Bone-patellar tendon-bone
BW	Body weight
CAPL	Canadian assessment of physical literacy
COD	Change of direction
DVJ	Drop vertical jump
FMS	Fundamental movement skills
GRF	Ground reaction force
ICRS	Cartilage repair assessment scale
IKDC	International knee documentation committee questionnaire
KOOS	Knee injury and osteoarthritis outcome score
KOOS-QOL	Knee injury and osteoarthritis outcome score- quality of life questionnaire
LESS	Landing error scoring system
LSI	Limb symmetry index
MCSD	Minimally clinically significant differences
MDC	Minimal detectable change
MIC	Minimally important changes
MOI	Mechanism of injury
N	Newton

NRS	Numerical rating scale
PL	Physical literacy
PSC	Perceived physical self-confidence scale
PROMs	Patient reported outcome measures
QT	Quadriceps tendon
REB	Research ethics board
ROM	Range of motion
RTP	Return to play\
RTS	Return to sport
SCI	Sport confidence inventory
SLH	Single leg hop
SD	Standard deviation
SDC	Smallest detectable changes
STG	Semitendinosus and gracilis tendon
VAS	Visual analog scale
vGRF	Vertical ground reaction force

CHAPTER 1: BACKGROUND

INTRODUCTION

The anterior cruciate ligament (ACL) injury is one of the most common knee injuries reported in sports medicine[1]. The current standard of care for active individuals is arthroscopic intra-articular autograft ACL reconstruction (ACLR) to restore rotational stabilization of the knee[2]. Although this injury has been studied extensively, the knowledge generated has not had a positive impact on prevalence as the number of ACL reconstructions performed in Manitoba continues to increase annually[3]. However, surgical intervention is just the first step as this is a severe injury with a lengthy recovery process that can result in physical and psychological responses[4–6]. Both the physical and mental responses to this injury can negatively impact emotional wellbeing[4–6], rehabilitation and a successful return to activity following surgery[4,7–9]. Therefore, emphasis has recently been placed on rehabilitative assessments that include both physical and psychological outcomes to positively impact future RTS rates[9,10].

CONSEQUNCES OF AN ACL INJURY

A common expectation following surgery is to return to the pre-injury level of competition at full performance[11]. Unfortunately, while 83% of patients may return to *a* sport[12], 45% to 60% do not return to their previous level of activity because of knee-related impairments[6,7,13,14]. This exposes suboptimal RTS rates and failure to achieve full functional restoration following ACLR surgery. For athletes, full functional restoration suggests both a return to the same competitive level, as well as the same performance capacity. Of the proportion of athletes that return to sport, it has been reported that 23-54% will reduce their playing level and an additional 13-17% will end their careers within three -years[15,16]. In addition to those returning to sport, a 37% risk of second ACL rupture (either reinjury or contralateral ACL) within the first two years following surgery also exists[8,17,18]. Ultimately, while some patient with an ACLR do return to play, many do so with functional impairments and a higher risk of subsequent ACL injury[19].

The consequences of an ACL injury extend beyond sport and are not fully resolved with surgical intervention. These can include higher prevalence of chronic knee pain[8], rates of recurrent lower limb muscle injuries[16], osteoarthritis and meniscal tears[20,21], incidence of contralateral tear or graft rupture[8,22], time away from activity, lifelong financial and socioeconomic burdens[23], as well as disability[24]. Inability to successfully achieve full functional restoration may lead to other long-term repercussions including lower moderate-to-vigorous activity levels, fewer daily step counts when compared to healthy individuals[25], a higher risk of chronic disease and associated comorbidities[4], emotional burden, and psychological stress[4]. Long-term outcomes between surgical reconstruction techniques are largely equivalent in terms of knee stability[26]; however, post-operative rehabilitation shows a wide range of differences in exercise prescription and RTS outcomes[26,27]. Consequently, insufficient use of rehabilitation and inappropriate and widely variable programming may contribute to the inability to achieve full functional restoration after ACLR[27–29].

Encouragingly, 91% of patients identify that they are "motivated and aspire to return to their sport following surgery" within the first year[30]. While the primary goal of surgical intervention is to restore joint stability and function[31], the goal of rehabilitation is to restore performance[32], facilitate the return to pre-injury activity levels[1], and improve quality of life[33]. However, there is mismatch between patient expectations and treatment effectiveness. Therefore, an opportunity exists to improve rehabilitation practices to meet both the patient's expectations, as well as the intended goals of ACLR.

RETURN-TO-SPORT

Surgery alone does not guarantee that a patient will return to their pre-injury level of performance[34,35] without elevated risk of subsequent injuries or impaired performance. Progressive rehabilitation enhances post-surgical outcomes and plays a vital role in assisting the patient to return to their previous lifestyle[1], which may include sport, active hobbies, or physically demanding occupations. The RTS assessment should be embedded within the rehabilitative continuum and utilized to evaluate the patient's readiness to return to sport/performance following ACLR while working towards total unrestricted play[36]. Although a consensus definition of RTS does not exist, most agree that it represents a continuum of three phases including return to participation, return to sport, and return to performance[20]. In the final return to performance phase, athletes with ACLR should be able to complete one (or more) seasons in the sport of injury at the same competition *and* performance level prior to injury[32].

Traditionally, common-criteria used to "clear" individuals to RTS include 1) meeting specific 'timepoints" in rehabilitation, 2) passing subjective criteria (i.e. clinical special tests), 3) using objective criteria based upon physical tests (i.e. isokinetic strength)[35] and 4) a combination of any of the above.

Timepoint Milestones

Time-based protocols enforce specified points-of-time before certain movements or exercises can begin. Time has traditionally been the main criteria used to determine when patients can return to full unrestricted sport[34,36]. This customarily occurs *no* sooner than 6 months post-operatively[35], but can range up to 24 months to "moderate the risk of re-injury"[37]. Considering time alone to clear athletes for RTS in the context of biological healing, rather than movement and skill acquisition, achievement of adequate strength and symmetry, and biopsychosocial activity is not sufficient[38]. Some have gone as far to state that temporal guidelines should be avoided all together[8,22], but according to Burgi et al[38] 42% (88 of 209) studies reviewed still relied on time alone!

Subjective Criteria

Subjective criteria rely heavily on the clinician's perception or "feel" of how the knee is healing during a clinical knee examination, and rarely involves evaluation of performance. As such, these criteria are largely focused on passive knee stability and healing, rather than functional restoration. A combination of special tests (i.e. Lachman, pivot shift, anterior drawer), lack of effusion, and full range of motion (ROM) are used to gauge satisfactory stability, laxity, and healing of the knee[35]. While this information is beneficial and informative, it only considers passive stability and healing with no consideration of dynamic function.

Objective Criteria

Objective or quantitative criteria commonly use physical testing and patient self-reported outcome measures (PROMs) as the primary tools of assessment. Isokinetic dynamometers for strength evaluations, in combination with many other functional performance measures like hop and jump tests[34,35,37] are typically deployed in ACLR RTS assessments. Scoring on objective functional tests during RTS assessments has traditionally relied on the limb symmetry index (LSI; Affected Limb Score / Unaffected Limb Score * 100%). A "passing" score is usually considered as 90% or greater between the unaffected and affected limb. An LSI of 90% or greater is used to ensure the ACLR limb has reached “an acceptable level or strength or function to minimize the risk of overuse and/or further injuries when returning to sport or strenuous work”[39], and is thought to be comparable to that seen within healthy, uninjured populations.

The use of the LSI is not without concern as it may be compromised when surgeries involve the harvest of material from the contralateral leg, in patients with a history of bilateral injury[40], detraining of the unaffected limb, or when considering the neurologically-mediated bilateral effects of ACL injury[21]. An obvious limitation of using symmetry alone is that even given symmetrical ability, the absolute level of performance may be substandard for performance at the competition level. Not surprisingly, performance deficits relative to uninjured controls have found impaired performance, even in the presence of comparable limb symmetry[37,41]. In this way symmetry tests are probably a good milestone, but have a shortcoming for predicting sport performance[41].

When using an LSI standard of 90%, Toole and colleagues[42] found that the majority of tested athletes (n=115) actually failed RTS tests, especially if the evaluation combined multiple tests into one session. While 53% of athletes could pass the single leg hop tests, only 27% could pass strength tests, and merely 13% could pass both hop and strength tests when combined in the same session. Even in the presence of symmetrical performance, asymmetric movement patterns may be utilized to achieve these scores[43]. Consequently, relying on LSI alone, even across various physical tests, is not sufficient.

Future RTS testing should consider both biomechanical and performance symmetry[39] in the context of pre-injury performance or normative values. Ultimately, RTS criteria should be multifactorial like the injury itself and reflect the demands of the sport[38]. Current quantification methodologies do not provide adequate information to determine readiness to RTS[41,44,45] and redundancy exists in the representation of certain domains (i.e. multiple hop tests)[8].

VALIDITY OF RETURN-TO-SPORT TESTS

The use of criterion-based physical testing is certainly beneficial when assessing readiness to RTS as it provides additional information to self-report questionnaires and the standard clinical exam. However, the large variety of available tests[4,36] and inconsistent use across studies reveals a lack of consensus in clinical decision making. Recently the validity of the RTS assessment process has come into question, considering the inability of current test batteries to predict RTS rates and risk of reinjury. It has been stated in the literature that passing RTS batteries should lower the risk of (any) subsequent knee injury[46]. However, a contradictory meta-analysis reported that although passing RTS criteria should reduce the risk of subsquent graft rupture, it does not reduce the risk of further knee injuries and actually *increases* the risk of contralateral ACL injury[36]. Unfortunately, these results are not without debate as the studies reported on included varying populations of athletes who had formally been cleared to RTS, those who chose to RTS without clearance, and those who had returned even though they had failed RTS[46]. Upon reanalysis of Webster & Hewett's meta-analysis, Capin et al[46] found that passing RTS test batteries is associated with 72% lower risk of further knee injury, 75% lower risk of graft rupture, and it is inconclusive whether there is a higher risk of contralateral ACL injuries. Due to conflicting reports on successful completion of RTS testing, these findings raise questions about the validity of the current RTS batteries to predict injury or successful RTS[43].

Improving RTS Assessment Methodology

Current RTS procedures yield information that may have clinical utility for treatment progression, yet the lack of predictive validity for reinjury risk and readiness to return to sport within a given time is concerning. This may be in part due to a heavy reliance on the LSI without consideration of standards of performance, and the limited ecological validity of lab-based testing methods.

Historically, RTS decisions have been almost entirely based on time, and more recently, on the physical domain of the athlete[38], but this ignores the psychological impact of the injury[17]. Deficits in strength, kinematics, proprioception, perception of knee function, *and* psychological readiness still persist at 2 years post-operation[4]. Emotions including fear of reinjury and cognitive factors including self-efficacy and motivation influence RTS decision making[47]. Emerging research suggests that RTS assessments could be improved with consideration of psychological factors, as the concept of “psychological readiness” is an important element for RTS[13,48]. As measures of readiness do not correlate with physical function[49], this requires specific measurement and possibly differing interventions to improve psychological readiness throughout the RTS process. Consequently a holistic definition of readiness must be incorporated into RTS assessments that considers physical function alongside psychological status[38].

Psychological Readiness

Many athletes do not return to their preinjury level of sport following ACLR even when satisfactory knee function is achieved[50]. This indicates that other factors outside of physical readiness influence RTS[36] and that physical and psychological readiness RTS do not always coincide[51] as they may be separate constructs[49]. Given the traumatic nature of the ACL injury, subsequent surgery, lengthy recovery and rehabilitation, there is no doubt that this can have a significant psychological effect on the individual beyond the more obvious physical ones. It is possible for patients to “pass” a RTS assessment with inadequate psychological readiness and/or knee confidence (confidence being a subdomain of psychological readiness) as revealed by the self-reported ACL-Return to Sport After Injury (ACL-RSI) and the Knee Injury and Osteoarthritis Outcome Score- Quality of Life (KOOS-QOL)[52,53]. Not addressing the psychology of the injury can present as negative emotions such as: anxiety, fear, hesitancy, and lack of confidence which can affect the recovery process[36]. Psychological readiness should be an important component of the RTS decision[5].

The ACL-RSI is an injury related confidence questionnaire which was designed in 2008 to evaluate psychological readiness to RTS following an ACLR[54]. The questionnaire contains 12 items on an 11-point numeric rating scale (NRS) ranging from 0 to 100 (intervals of 10) and a total score is computed by summing all the responses together. The ACL-RSI considers three domains; confidence in performance (5/12 items), emotional well-being (5/12), and risk appraisal relative to the sport and injury (2/12)[51]. A high score on the ACL-RSI is indicative of a positive psychological response that may signify readiness to RTS[46,54], and low scores could be used to identify patients at high risk for not returning to sport[54]. The ACL-RSI has been shown to differ between patients who have returned to sport, returned at or above preinjury levels of play, or failed to RTS following ACLR[51,55–58]. Early responses on the ACL-RSI are also predictive of subsequent ability to return to sport by 12- and 24-months post-operative[54,59].

The predictive ability of the ACL-RSI may also be improved when considered alongside measures of physical function. Müller et al[58] found the single leg hop LSI and ACL-RSI score were predictive of returning to sport at preinjury capacity at seven months post-operative

(Sensitivity 0.97, Specificity 0.63; LSI > 75.4%, ACL-RSI > 51.3). Kitaguchi et al[10] replicated these findings, suggesting the combination of single leg hop LSI and the ACL-RSI at six months post-operative could identify 91% of athletes that did not return to sport (LSI < 81.3 %, ACL-RSI < 55 points).

While it is often assumed that psychological responses occur in tandem with improved physical function during the post-operative period, recent evidence suggests these do not always correlate[49]. One way we can begin to evaluate psychological readiness is to expand upon the ACL-RSI questionnaire. The ACL-RSI considers confidence as it pertains to the surgically reconstructed knee and the patient's sport, but it does not recognize how confidence may vary based on the task being evaluated.

CONFIDENCE

Confidence is defined as the belief that one possesses about their ability to be successful. When developed in sport it can lead to many positive attributes such as; lower cognitive and somatic anxiety, adaptive goal orientation, improved flow state, and better performance[60]. Conversely, when confidence is eroded, it can lead to an increase in negative emotions and behaviors, inability to manage anxiety, impact on decision making processes[61], and can negatively affect recovery[9]. High self-efficacy (confidence) increases one's likelihood for success as tasks are perceived as achievable challenges, whereas low efficacy leads to decreased efforts and belief within one's self[61]. Psychological components, including confidence[56], may account for some of the deficits observed during RTS evaluations[8]. According to Machida et al[60] confidence is the most influential and widely studied psychological construct in sport within *healthy* populations and often the main focus when assisting athletes improve their performance.

Despite this, confidence is rarely measured in rehabilitation or as a component of the RTS process even though improving performance is one of the main components of RTS testing.

Interestingly, task-specific confidence has been a central component of the fundamental movement pattern assessment in youth. Physical literacy (PL) has made tremendous strides in exploring how developing confidence in specific skills can lead to movement competence[62]. PL specifically entails the benefits of simultaneously developing movement-related confidence with competence in a positive-feedback-cycle to encourage and maintain the adherence to physical activity[62–64]. When competence and confidence are used in this engagement cycle they are thought to be both reciprocating and reinforcing[63]. If confidence is lacking or not developed, it may lead to the withdrawal from participation in physical activity (sport or free play)[64] creating a negative movement reduction cycle. Assessing both movement proficiency and psychological variables, such as confidence, is commonly performed in physical education and recreation with youth to ensure an optimal learning environment and success in skill achievement[64]. That same framework could be used to increase patient confidence in a rehabilitative setting to develop motor skill proficiency regardless of age of injury status[65].

Confidence and Rehabilitation

The assessment of confidence within rehabilitation is a relatively new and emerging field. With sport psychology and PL emphasising the benefits of confidence, it is unfortunate that the most recent ACL studies report high levels of patients with low levels of confidence. Hart et al[66] reported that 82% of ACLR patients had reduced confidence towards their reconstructed knee one year post-operatively, Paterno et al[53] reported that 62% of the participants lacked confidence in their knee at their medical clearance exam (8.4+/-2.6 months post ACLR), and Webster and colleagues[51] found that athletes with injuries (not specifically ACL ruptures) had lower levels of confidence than uninjured athletes which *persisted* upon returning to sport post-injury. There is currently no one-way to assess confidence in rehabilitation, but the literature identifies using general measures to gauge confidence such as the; the KOOS, QOL, Tampa Kinesiophobia Scale, and the ACL-RSI (which measures confidence as a subdomain of psychological readiness to RTS)[5,42,54,55].

There are also no definitions or criteria in place to identify a low- or overly-confident person. It is also unknown how much or how little confidence is most beneficial when it comes to RTS, performance, or preventing risk of secondary injuries but strides are currently being made in the literature to answer this question. Paterno and colleagues[53] used the KOOS-QOL questionnaire to evaluate general knee confidence and categorized their study population into two groups; high confidence and lacking confidence groups. They found that the high confidence group of ACLR patients were more likely to perform better during the RTS testing (PROMS, isokinetic strength testing, and hop tests) and were more likely to "pass" all the RTS testing criteria (LSI >90%). Yet these highly confident patients were also more likely to sustain a secondary ACL injury within 24 months of returning to sport when compared to those lacking confidence (31.7% vs 16.2%). Piussi and colleagues[22] recently reported similar findings where patients with a stronger psychological profile (as assessed by the ACL-RSI short-form questionnaire) had an increased risk for a secondary ACL injury within 2 years of their initial reconstruction. Although the high confident group of patients in Paterno's study were younger than the group lacking confidence, there were no other demographic differences and the increased risk of a secondary injury was thought to be related to intensity of play upon RTS[53]. For these reasons, the optimal level of confidence one should possess upon returning to sport needs further evaluation, but this study also highlights the fact that current RTS testing batteries may not adequately prepare patients to return to high intensity sport demands. It should also be noted that the KOOS-QOL evaluates general knee confidence and therefore the group categorized as high confidence could still be lacking task-specific confidence to complete some of the movements required of their sport. This may justify the implementation a testing battery that evaluates task-specific confidence versus general confidence, but also the importance of physically testing sport specific tasks in addition to confidence. It is the amalgamation of all of these factors which may provide the greatest diversity of information when trying to minimize the risk of a secondary injury and a successful RTS.

Hart and colleagues[5] have been among the first to assess general confidence (using items from the KOOS and ACL-RSI), task-specific knee confidence and performance in patients following ACLR. Task-specific knee confidence was assessed by having patients rate their confidence immediately following performance-based functional tasks (i.e single leg hop, cross-over hop, and timed side-to-side hop) on a 10 cm visual analog scale (VAS, with 10 representing maximum knee confidence)[66]. Low levels of tasks-specific confidence were associated with lower ACL-RSI scores and reduced hopping performance, and those with higher ACL-RSI scores (i.e., greater psychological readiness) performed better. While previous studies have demonstrated a dissociation between psychological measures of readiness and performance[49], it is possible that task-specific confidence may have a stronger association to performance than measures of psychological readiness. Unfortunately, Hart et al[5] did not directly assess the relationship between performance and task-specific confidence of both the affected and unaffected limbs and how that would relate to the ACL-RSI.

These contradictory results highlight the importance of further investigation into the impact confidence has on the patient. The studies above reveal that high confidence may result in optimal performance and the ability to pass RTS batteries, but that it also may result in a higher risk of re-injury. Task- and limb-specific measures of psychological factors provide useful information about a patient's perception to perform a specific task[5] throughout the rehabilitative process and could guide further treatment. It is possible for confidence to vary on the basis of assessment, relative to the injury itself, the sport, or task. Anecdotally, it is not uncommon over the rehabilitative process to see varying levels of confidence based on task. For example, patients may report high levels of confidence on straight-line jogging, yet low confidence with high-speed changes in direction. Successful RTS following ACLR requires optimal physical *and* psychological recovery[55], yet current assessment methodologies assess physical readiness moreso than psychological outcomes[38]. This could be the difference of feeling confident in a testing environment (controlled environment) versus on the field of play (uncontrolled environment). If patients are not confident in executing simple movements (i.e. SLH) following ACLR, we cannot expect them to feel confident stringing together a multi- movement repertoire (i.e. basketball layup), yet that is generally our expectation when we clear a patient to return-to-sport based on simple measures of impairment.

SUMMARY

Despite the historical reliance on physical assessments to inform the RTS process[35], evaluating psychological responses following the ACL injury may influence and positively impact rehabilitation and RTS rates[9]. High levels of confidence and self-efficacy are thought to be important factors for successful adherence to rehabilitation and subsequent outcomes[5,9]. There is a gap in our understanding concerning the relationship between the patient's injury related readiness (ACL-RSI), task-specific confidence, and performance. Assessing task-specific confidence in conjunction with performance may yield additional insight into guiding rehabilitation progressions and making decisions regarding readiness to RTS.

CHAPTER 2: METHODOLGY

PURPOSE

The primary purpose of this study was to examine between-limb differences in confidence, psychological readiness (ACL-RSI) and self-reported and assessor-rated task-specific confidence in participants at 6-months following ACLR in relation to performance on three common functional tasks used in RTS assessment.

OBJECTIVES

1. a) To determine if there is a difference in task-specific confidence between the unaffected and affected limbs for the single leg hop (SLH), change of direction (COD), and drop vertical jump (DVJ) tasks as rated by the participants and a clinical assessor.
1. b) To assess the degree of correlation and agreement between the participant's and assessor's ratings of confidence.
2. To determine the degree of correlation between LSI or affected limb performance scores and ratings of confidence in the SLH, COD, DVJ.
3. To assess the degree of correlation between an existing injury-specific PROM (ACL-RSI) and measures of task-specific confidence across the three tasks: SLH, COD, and DVJ as assessed by the participant and an assessor.

HYPOTHESES

(1) Given that there are expected performance differences between limbs, it is hypothesized that both the assessor and participant will rate confidence of the unaffected limb higher than the confidence of the affected limb for all tasks. Based on pilot data, it is anticipated that the ratings

of task-specific confidence between the assessor and participants will have low agreement but a moderate correlation for the affected and unaffected limbs across all three functional tasks. (2) Based on previous research in the field[5,49], it is hypothesized that there will be a moderate correlation between absolute performance and task-specific ratings of confidence for the three functional tasks made by the participant and the assessor, but there will be a low correlation between task-specific ratings of confidence and LSI for the three tasks; and (3) there will be a strong correlation between the injury-specific PROM (ACL-RSI) and participant and assessor task-specific ratings of confidence across the three functional tasks, a moderate correlation between the ACL-RSI and absolute performance for the affected limb across the three functional tasks, and a no correlation between the ACL-RSI and LSI for the three functional tasks.

METHODS

This thesis is a cross-sectional observational comparison embedded within an existing longitudinal trial called "Number one overall graft pick? Hamstring vs Bone-patellar tendon-bone vs Quadriceps tendon: A Prospective Cohort Study" (ACL GC). All study activities occurred at a sports medicine research centre (Pan Am Clinic Foundation, Winnipeg, MB, Canada). The existing longitudinal study commenced August 2018 and is predicted to continue until the winter of 2026. Ethics approval was obtained from the local review board of the University of Manitoba prior to the initiation of any study activities for ACL GC (REB #: B2016:066). An amendment was submitted to and approved by the Research Ethics Board related to the proposed to include the methodology for the cross-sectional comparison (Appendix I).

Participant Inclusion Criteria

All study participants sustained a unilateral ACL rupture and had ACL reconstructive surgery using a quadriceps (QT), semitendinosus and gracilis (STG), or bone-patellar-tendon-bone (BPTB) graft by one of five orthopaedic surgeons participating in the study prior to inclusion. Throughout the duration of the study, two surgeons used QT grafts, two surgeons used BPTB grafts, and one surgeon used STG grafts.

Participants (male and female, aged 14-50) were included if they had a complete ACL tear with no other ligament injuries requiring surgical intervention, and participated in any sport or activity of any level of play. Participants were excluded if they had one of the following; a previous ligament surgery on the affected or contralateral limb, severe chondromalacia (Grade IV on the cartilage repair assessment scale (ICRS)), a confirmed connective tissue disorder, the injury was associated with a Workers Compensation Board claim, unwillingness to be followed for six months post-operatively (the ACL GC trial requires 24 months post-operatively), history of rheumatoid arthritis, pregnancy at the time of surgery, psychiatric illness that precludes informed consent, major medical illness (life expectancy less than one year or unacceptably high operative risk), and/or the inability to speak, read, or understand the English language.

Study Visit Procedure

The participants were evaluated at their post-surgical 6-month follow up appointment. The order of the tests was based on exercise performance sequencing placing more energy demanding tasks first; power, strength, then strength-endurance.

Physical Performance Measures

Each participant completed three performance tasks: a DVJ (3 trials), a COD task (4 trials, 2 for each leg), and a SLH (4 trials, 2 for each leg). The participant was familiarized with each task prior to execution and 5 minutes of rest was given between tasks. The three performance tasks were video recorded to facilitate any required review following the appointment using three 2D cameras (GoPro, CA, USA) stationed around the participant on tripods. One camera was positioned to observe the frontal plane (either anteriorly or posteriorly depending on the direction that the participant was moving) and two cameras observed the sagittal plane for each limb. All of the functional tasks were intended to be maximal effort, but if the participant was not comfortable executing the tasks at maximal effort, they were instructed to perform the task to the best of their ability and within their comfort level.

Drop Vertical Jump Task

The participant was instructed on how to perform the DVJ and led through three progressions and three practice trials for familiarization. The initial progressions included: jumping down from a 30 cm plyometric box and landing on the ground immediately in front of the box, jumping from the box to the force plates positioned with their mid-point at 50% of the participant's height, and jumping from the box to the force plates and immediately performing a vertical jump and landing back on the force plates at an estimated 50% effort level. Following the familiarization period, the cameras were turned on and the participant was asked to complete the three DVJs at maximal effort. The DVJ required the participant to drop jump forward from a 30 cm box, land on two force plates (one under each foot) positioned 50% of the participant's height away from the box[67], perform a maximal effort counter-movement vertical jump, and land back on the force plates (Appendix II). The participant was allowed to use their arms to assist with the movement and to aid with balance while performing the task. No rest was given between the three trials as the participant was instructed to complete all three jumps as fluidly as possible. If the participant made an error, the task was terminated, and the participant restarted the three DVJ trials.

Change of Direction Task

The COD task[68] was explained to the participant, and they were given up to three practice trials on each limb and instructed to perform the practice trials starting at low intensity, followed by up to two higher intensity familiarization repetitions. The participants were asked to complete the task using maximal effort and were given rest as needed between each trial and an additional 5 minutes of rest before starting the third task. The participant was instructed to run in a straight line, 15 meters towards a marker on the floor, plant their test foot (left or right) on the marker, and turn and run back towards the original start line (Appendix III). Photocell timing gates (Brower Timing System, Salt Lake City, USA) were placed 10 meters from the start line, timing the participant as they completed a 180-degree change of direction, running for 5 meters both pre- and post-direction change. The participant was tested twice on each side, alternating with each trial.

Single Leg Hop for Distance Task

The SLH was explained to the participant and they were given three practice trials on each foot, starting with a sub-maximal test followed by increasing effort to near-maximum-effort. The participant was instructed to perform a maximal effort single leg hop for distance, starting on their unaffected foot and landing on the unaffected foot. Participants were instructed to "stick" their landing (i.e., the ability to plant the test foot without shifting forward, backwards, or losing their balance) and hold that single foot landing for 2 seconds (Appendix IV). At that time a recording was taken of the distance hopped in centimeters (measuring from the toe at the start line to the heel where they landed). The participant was allowed to use their arms to assist the movement but was not allowed to touch the ground with the hands to help maintain balance. Two acceptable trials on either limb were recorded, alternating sides with each trial. An enforced rest between trials was not given as the participant was alternating limbs between trials, and a prolonged rest between trials was only given if requested by the participant. Trials were discarded if improper technique was utilized or if there was a difference of ~10% between hops and in those cases an additional trial was performed.

Assessment of Confidence

Immediately following completion of each of the three tasks the participants were asked to rate their confidence by pointing to an 11-point numeric rating scale in the form of boxes from 0 to 10 (Appendix V). A clinician posed the question as follows:

- DVJ Test: "on a scale of 0 to 10, 0 being not confident and 10 being fully confident, please point to the number on the scale to indicate how confident you felt while performing the three jumps? Using the same scale please indicate how confident you felt performing the three jumps on your right/left side?"
- 5-0-5 COD Test: "on a scale of 0 to 10, 0 being not confident and 10 being fully confident, please point to the number on the scale to indicate how confident you felt while performing this task and having to plant on your right/left foot?"

- Single Leg Hop Test: “on a scale of 0 to 10, 0 being not confident and 10 being fully confident, please point to the number on the scale to indicate how confident you felt while hopping on your right/left?”

Assessor #1 was blinded to the participant’s ratings of confidence and provided an observer rating of task-specific perceived confidence following completion of each test utilizing the same NRS. This represents a preliminary investigation into the differences between participant and assessor perception of task-specific confidence, and while the specific determinants of the assessor’s perception of movement confidence are not known, a theoretical example of potential contributors during the single leg hop test is provided in Table 1.

Assessment of Confidence using PROMs (ACL-RSI)

Once the three functional tasks had been completed and the ratings of confidence had been recorded, the participants completed the ACL-RSI (Appendix VI). The ACL-RSI has shown to be valid and reliable[51], it contains 12 questions, each question is scored with an 11-point numeric rating scale in the form of 10-point increments boxes from 0 to 100 and is scored out of 120 points. It is divided into three subdomains to assess psychological readiness across confidence, emotional well-being, and risk appraisal regarding their reconstructed ACL and overall knee wellbeing. A high score is indicative of positive psychological responses[45,54].

Table 1. Potential contributing factors of a clinician's perception of patient confidence

	Displaying Confidence	**Lacking Confidence**
Preliminary actions prior to task execution	- listens to task description - willing to try the task - no obvious apprehension - no obvious fear - open/poised body posture - does not feel the need to practice the task, or require additional practiced trials	- uninterested in the task - questions the task - apprehensive/ fearful to perform task - self-talk or looking to assessors for reassurance to perform task - hesitant/anxious preliminary movements - requests additional practice
During the task	- quiet landing - ability to stick the landing with little compensatory movements - ability to balance on the stance leg - content with performance or strategizing on how to do better	- loud landing - rigid limb/body throughout task -immediately places the unaffected foot on the ground during landing -fails to fully leave the ground during the hop, shuffling the foot forward on the ground
Upon task completion	- upright body posture - desire to "do better" - eye contact - happy - positive self-talk	- poor body posture - excuses for distance jumped or poor landing - lack of eye contact - demotivated - negative self-talk

Ratings of Confidence between Clinical Assessors

To evaluate inter-rater reliability, a second assessor (Assessor #2) was recruited to rate the perceived confidence of the participants to be compared to the first assessor's (Assessor #1) ratings of confidence. Assessor #2 rated confidence via video analysis of 15 randomly selected participants. To establish consistency and similarity between the two assessors and the rating conditions, Assessor #2 was selected based on their professional background (Athletic Therapy) and familiarity assessing patients following ACLR. Assessor #2 was given Table 1 (Contributing Factors of Perception of Confidence), the confidence NRS, and a brief instructional video example with Assessor #1 before beginning his ratings of confidence. Comparable to Assessor #1, Assessor #2 was blinded to the participant's ratings of confidence, but was given the participant's age, sex, graft type, treating surgeon, and surgical limb side. The order that Assessor #2 reviewed the functional tasks was consistent with the live assessment. Assessor #2 was instructed to watch each video clip once, without pausing or stopping the task to mirror the live assessment. Full results are attached (Appendix VIII).

ANALYSIS

Sample Size Determination

A priori sample size calculations were completed for the outcome of rater agreement using data collected on the affected limb confidence ratings for the 505 change of direction test on a subset of pilot participants (n=47). Participant confidence ratings (range 7, min 3 max 10, mode 7, median 7) and assessor-ratings (range 6, min 3 max 9 mode 7, median 7) were compared with a Cohen's K of -0.089, and a Spearman's Rho of 0.196 (p=0.0187), indicating minimal agreement and correlation between the raters. An 11x11 contingency table was created using observed response frequencies and estimated proportions derived from the pilot subset (Table 2). With a power of 0.80, alpha of 0.05, and null hypothesis (k=0) against an alternate hypothesis (k>0.5), a minimum sample size of 17 individuals was found to be required.

G*Power[69] was used to complete an additional *a priori* power analysis considering the secondary outcome of between-limb differences in patient-rated confidence. Using affected (Median 7, Mode 7, Min 3 Max 10) and unaffected (Median 9, Mode 10, Min 6, Max 10) limb participant rated confidence values collected during the COD task, an effect size was estimated as z/sqrt(n) = -0.86 (z = -5.903, n = 47). Assuming alpha of 0.05 and power 0.8 a minimum total sample size of 14 was required. When considering the potential for dropout (i.e., inability to complete the single testing session) of 20%, a minimum sample of 21 participants ensured comparisons were adequately powered.

Table 2. Cumulative percentages of confidence ratings between participant and assessor (pilot data)

Confidence Rating	Observed Patient Responses (%)	Observed Clinician Response (%)	Estimated Proportions
0	0	0	0.001
1	0	0	0.001
2	0	0	0.001
3	4.3	6.4	0.042
4	10.6	10.6	0.063
5	25.5	19.1	0.149
6	42.6	34	0.171
7	72.3	63.8	0.297
8	91.5	83	0.192
9	97.9	100	0.063
10	100	0	0.02

Statistical Analysis

All data was analyzed using SPSS (v 27; IBM Corp., NY, USA) and graphs prepared using GraphPad Prism 9.2.0 (Graphpad Software, CA, USA). Continuous variables (performance data) were summarized using mean and standard deviation (SD), while ordinal variables (confidence data) were summarized using the median and range. Descriptive statistics were used to summarize participant characteristics.

Objective #1:

- The difference in the participant's and the assessor's confidence ratings between the unaffected and affected limbs was evaluated using Wilcoxon signed-rank test.
- Cohen's Kappa statistic was used to determine the level of agreement and Spearman's rank-order correlation test was used to determine the correlation between the participant's and the assessor's ratings of confidence per limb and by task.
- The Friedman test was used to assess the difference between affected limb confidence ratings made by the participants and assessor across the three tasks to determine if confidence varied by task. Friedman test was also used to evaluate if there was a difference between overall, unaffected, and affected limb confidence ratings made by the participants and the assessor for the DVJ.

Objective #2:

- Paired-samples t-tests were used to evaluate absolute performance differences between the unaffected and affected limbs across the three performance tasks while a one-way ANOVA was used on LSI across the tasks.
- Spearman's rank-order correlations were used to determine if correlations existed between the participant's ratings of confidence and their performance (absolute and LSI)

per limb and by task, and to evaluate correlations between the assessor's ratings of confidence and the participant's performance (absolute and LSI) per limb and by task.

- The participant's confidence ratings were categorized and divided into high (≥ 8/10) and low (≤ 7/10) confidence groups. Independent-samples t-tests were then used to evaluate if a difference in performance existed between the high confidence group and the low confidence group for the SLH on the affected limb.

Objective #3:

- Spearman's rank-order correlation test was used to evaluate correlations between the participant's ratings of confidence (per limb and by task) and ACL-RSI scores, between the assessor's ratings of confidence (per limb and by tasks) and ACL-RSI scores, and between the participant's performance measures (per limb and by task) and the ACL-RSI questionnaire scores.

In all cases, significance was considered at $p<0.05$. Effect size magnitudes were classified as small 0.2, medium 0.5, large 0.8, very large 1.3[70]. Kappa values of agreement were classified as $\kappa \leq 0.2$, 0.21-0.39, 0.4-0.59, 0.60-0.79 0.80-0.90 and ≥0.90 as no, minimal, weak, moderate, strong and almost perfect agreement respectively[71], Spearman's ρ was classified as <0.2, 0.3-0.59, 0.6-0.79, 0.8-0.99 and 1.0 as poor, fair, moderate, very strong and perfect[72].

Force Plate Data Processing

Two adjacent force plates synchronously measured peak vertical ground reaction forces (vGRF) of either foot recording at 200 Hz. Peak vGRFs were recorded upon the initial landing of the first jump from the plyometric box to the force plates, the take-off phase of the subsequent vertical jump, and the final landing from the vertical jump. This was expressed in Newtons (N) and normalized to body weight ($N \cdot kg^{-1}$) ($N \cdot kg^{-1} = N/(\text{participant's kg} \times 9.81)$).

The vGRF of each limb for each phase/trial was graphed and analyzed in Excel and used to determine the peak forces for the affected and unaffected limbs for each phase of the jump, the participant's limb symmetry index for each phase, and jump height which was calculated from the participant's time in air during the maximal effort vertical jump, jump height = $(0.5 \times 9.81)((\text{time in air}/2)^2) \times 100$ [73]. The DVJ was subdivided into four phases to be analyzed in greater detail, phases are depicted in Figure 1:

- Phase 1 (P1): the peak force of the initial landing of the jump from the box to the force plates (eccentric).
- Phase 2 (P2): peak force of the takeoff phase for the vertical jump (concentric)
- Phase 3 (P3): time in air as the participant's feet leave the force plates from the concentric takeoff to the eccentric landing from vertical jump.
- Phase 4 (P4): peak force of the second landing from the vertical jump to the force plates (eccentric).

All phases of the DVJ were analyzed, but the vGRF from the initial eccentric landing (P1) was used to compare the DVJ to the SLH and COD tasks. P1 was selected for comparison over P2 and P4 because P1 had the poorest LSI across the phases (P1 LSI: 74.03 ± 25.40%, P2 LSI: 87.44 ± 9.51% , P4 LSI: 84.97 ± 32.35%) . P1 has also been shown in prior studies as a possible mechanism of knee injuries due to the asymmetric landing patterns injuries[19].

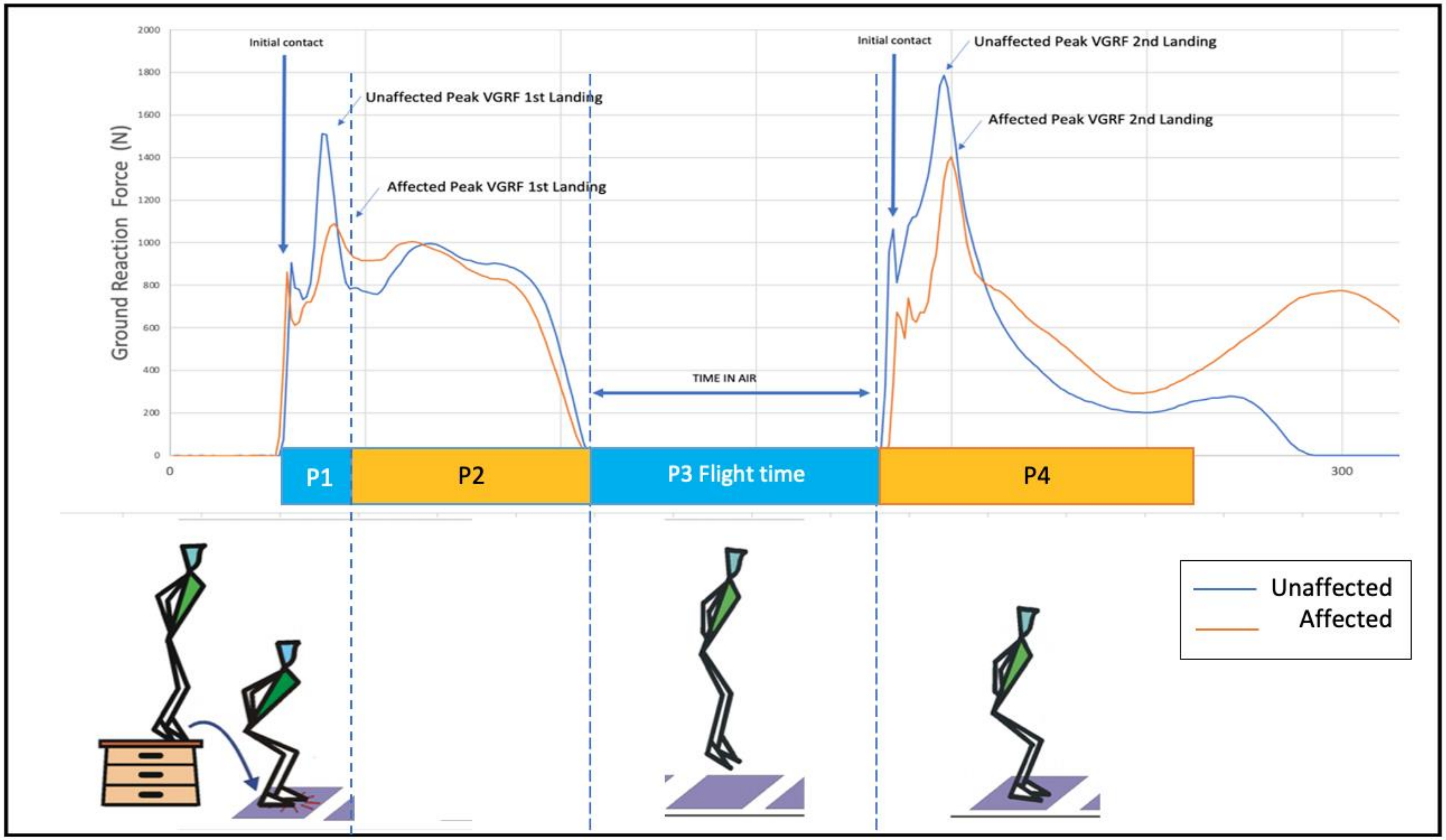

Figure 1. Representation of drop vertical jump vGRF
Each drop vertical jump was divided into four phases as identified on the chart which separated eccentric loading (P1 & P4) from concentric loading (P2), and time in air during the vertical jump as flight time (P3).

CHAPTER 3: RESULTS

Participant Demographics

A total of 32 participants completed their RTS testing at 6.33 ± 0.51 months post-operative and their characteristics are shown in Table 3.

Table 3. Participant characteristics

Age (years)	25.6 ± 8.5
Sex	
Male (%)	12 (37%)
Female (%)	20 (63%)
Height (cm)	172.6 ± 8.3
Mass (kg)	82.4 ± 22.2
Graft type (n)	
Quad	9
STG	9
BPTB	14
Time to surgery (days)	376.16 ± 302.8 (22-1168)
Tegner	
Pre-injury	7 (5-10)
6mth post-op	5 (2-9)
ACL-RSI	50 ± 22 (14-96)

Values represents mean ± standard deviation (SD). Time to surgery, Tegner, and the ACL-RSI included median ± SD (range) *Quad* quadriceps tendon, *STG* semitendinosus and gracilis tendon, *BPTB* bone-patellar-tendon-bone, *ACL-RSI* anterior cruciate ligament return to sport after injury

Performance Data

Table 4 summarizes the side-to-side results of the three performance tasks and graphically depicted in Figure 2. Affected limb SLH was reduced relative to the unaffected limb (mean difference 29.37cm, 95%CI 20.04 – 38.70, $t_{(32)}$ = 6.42, p<0.001, d=1.135). Affected limb COD had a marginal difference and slightly quicker completion times compared to unaffected limb (mean difference 0.04s, 95%CI 0.0006 – 0.086, $t_{(32)}$ = 2.071, p=0.047, d=0.366). Affected limb DVJ vGRF was reduced relative to the unaffected limb (mean difference 0.68 $N \cdot kg^{-1}$, 95%CI 0.44-0.91, $t_{(32)}$ = -5.84, p<0.001, d=1.032). DVJ average jump height was 20.24 ± 8.40cm.

LSI differed by task ($F_{(3,93)}$= 17.582, p<0.001) with minimal differences for the COD (101.38 ± 3.536% LSI, 95%CI = 100.11-102.65%) while the SLH (74.72 ± 18.44%, 95%CI = 68.07-81.36%, p<0.001) and DVJ vGRF (74.03 ± 25.40%, 95%CI 64.07-82.38%, p<0.001) were reduced relative to COD (Figure 3).

Table 4. Larger performance asymmetries for the SLH and DVJ compared to the COD

	Affected	**Unaffected**	**Mean Difference (95%CI), effect size**	**LSI %**
SLH (cm)	88.30 ± 41.41	117.66 ± 42.15	29.37 (20.04-38.70) ** d=1.135	74.71 ± 18.44
COD (s)	3.32 ± 0.51	3.36 ± 0.52	0.04 (0.0006-0.09) * d = 0.366	101.40 ± 3.54 †
DVJ vGRF ($N \cdot kg^{-1}$)	1.62 ± 0.56	2.30 ± 0.59	0.68 (0.44-0.91) ** d = 1.032	74.03 ± 22.17

Values represent mean +/- SD
CI confidence interval, *d* effect size, *LSI %* limb symmetry index, *SLH* single leg hop, *cm* centimetres, *COD* change of direction, *s* seconds, *DVJ* drop vertical jump, v*GRF* vertical ground reaction force, $N \cdot kg^{-1}$ Newtons per body weight
Statistical significance between limbs denoted by * p<0.050, ** p<0.001, † denotes significance at p<0.001 for LSI% comparison

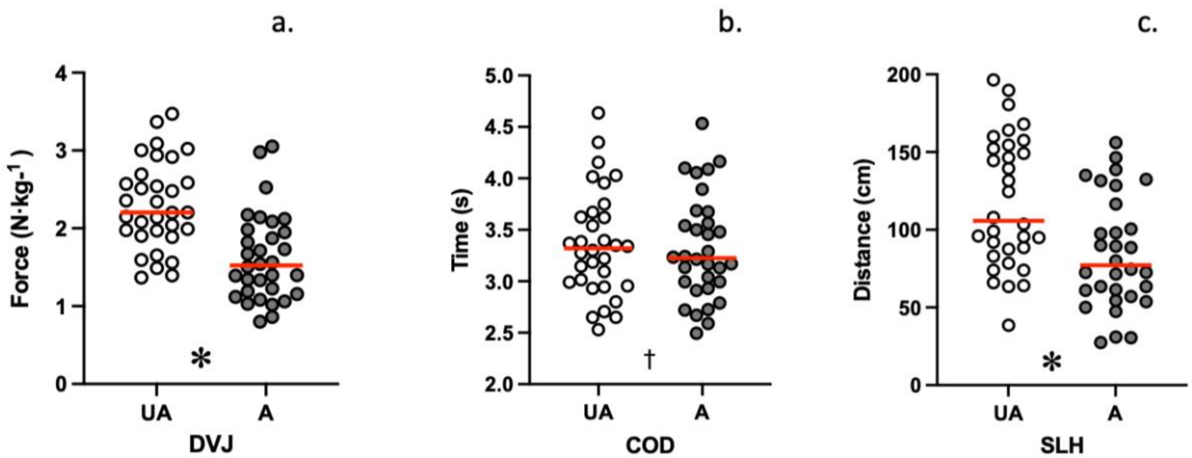

Figure 2. Comparison between the performance data for the unaffected (UA) and affected (A) limbs across the drop vertical jump (a.), change of direction (b.) and (c.) single leg hop
DVJ drop vertical jump, *N·kg-1* Newtons per body weight, *SLH* single leg hop, *cm* centimetres, *COD* change of direction, *s* seconds,
Statistical significance between limbs denoted by † p<0.050, * p<0.001, red bar denotes group mean

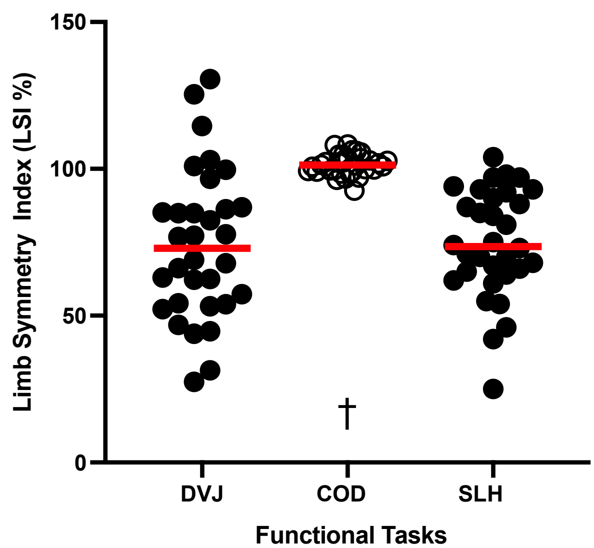

Figure 3. Minimal performance differences between limbs for the COD as depicted by the limb symmetry index percentage (LSI%)
DVJ drop vertical jump, *COD* change of direction, *SLH* single leg hop
Statistical significance for LSI comparison denoted by † p<0.001, red bar denotes task LSI% of the group

Confidence Data

Participant and Assessor Task-Specific Confidence Ratings

The participants rated their confidence on the affected limb lower than the unaffected limb for the SLH (Z=-4.754, p<0.001), COD (Z=-4.676, p <0.001), and DVJ (Z = -4.771, p <0.001; Table 5). The assessor also rated confidence lower on the affected limb compared to the unaffected limb for all of the performance tasks, SLH (Z=-4.750, p<0.001), COD (Z=-4.099, p<0.001), DVJ (Z=-4.737, p <0.001; Figure 4). The median difference between limbs for each performance task for the participant was SLH (3), COD (2), DVJ (4), and for the assessor SLH (3), COD (1), and DVJ (2). Results displayed in Table 5.

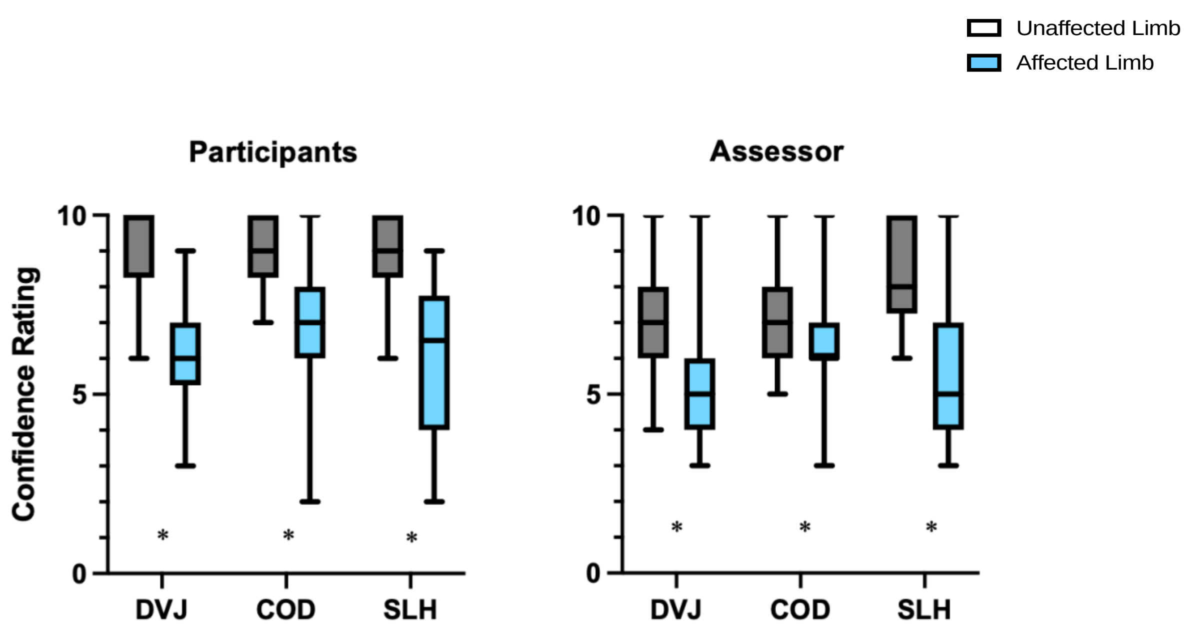

Figure 4. Both the participants and the assessor rate confidence of the affected limb lower than the unaffected limb

DVJ drop vertical jump, *COD* change-of-direction, *SLH* single leg hop

Statistical significance between limbs denoted by * p<0.001

Table 5. Confidence ratings are lower on the affected side regardless of task or rater

	Participant			Assessor		
	Affected	Unaffected	Difference	Affected	Unaffected	Difference
SLH	6 (2-9)	9** (6-10)	3	5 (3-10)	8** (6-10)	3
COD	7 (3-9)	9** (7-10)	2	6 (3-10)	7** (5-10)	1
DVJ	6 (3-9)	10** (6-10)	4	5 (3-10)	7** (4-10)	2

Difference in confidence ratings between limbs, values represent median (range)
SLH single leg hop, *COD* change of direction, *DVJ* drop vertical jump
Statistical significance denoted by * $p<0.050$, ** $p<0.001$

Overall Confidence is Different than Limb Specific Confidence for the DVJ

Participant's DVJ ratings for overall confidence were different from their ratings of limb-specific confidence ($X^2(2)=48.054$, $p<0.001$), overall compared to unaffected (Z=-4.695, $p<0.001$), overall to affected (Z=-2.441, p=0.015), unaffected and affected (Z=-4.77, $p<0.001$). The median values for the confidence ratings were, overall 7/10 (2-9), unaffected 10/10 (6-10), and affected 6/10 (3-9).

Affected Limb Confidence varies by Task

Participant's confidence ratings of the affected limb differed between two of the three tasks, ($X^2(2)=8.811$, p=0.012), DVJ and COD (Z=-2.172, p=0.030), SLH and COD (Z=-3.073, p=0.002), DVJ and SLH (Z=-9.47, p=0.344) as displayed in Figure 5.

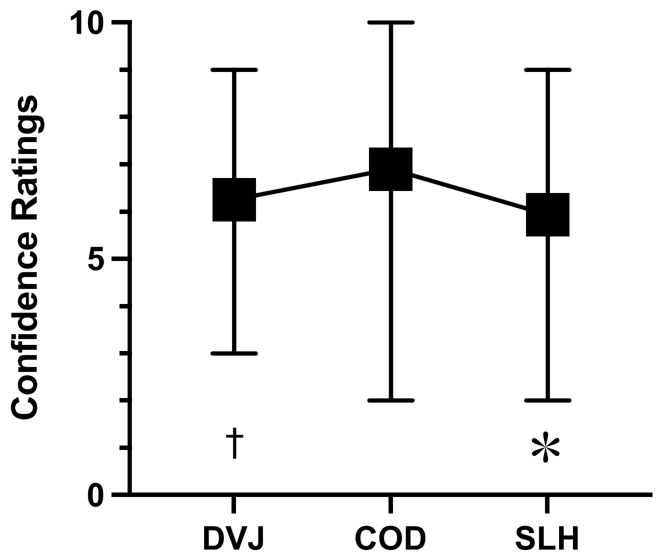

Figure 5. Confidence varied between change of direction task and jumping tasks
DVJ drop vertical jump, *COD* change-of-direction, *SLH* single leg hop
Statistical significance between tasks denoted by † p<0.050, * p<0.001

Correlation and Agreement of Confidence between Raters

Assessor #1 and Participants

There was no-to-minimal agreement and poor-to-moderate correlation between participant- and assessor-rated confidence for the affected limb: SLH (κ=0.109, 95% CI=0.042-0.269, p=0.079; ρ=0.632, p<0.001), COD (κ=0.168, 95% CI=0.001-0.335, p=0.022; ρ=0.290, p=0.108), and DVJ (κ=0.027, 95% CI=0.136-0.190, p=0.713; ρ=0.049, p=0.788). There was no agreement and poor-to-fair correlation between raters of confidence for the unaffected limb across the three tasks: SLH (κ=0.025, 95% CI=0.130-0.180, p=0.771; ρ=0.293, p=0.103), DVJ (κ=0.100, 95% CI=0.025-0.224, p=0.083; ρ=0.041, p=0.824), COD (κ=0.056, 95% CI=0.081-0.193, p=0.373; ρ=-0.368, p=0.038). There was no agreement and poor correlation between the participant and assessor's rating of both limbs (overall confidence) for the DVJ (κ=0.044, 95% CI=0.123-0.211, p=0.570; ρ=0.287, p=0.112). Results displayed in Table 6.

Table 6. Low agreement and correlation between the participant's and the assessor's rating of confidence

	Agreement			Correlation		
Task	Unaffected	Affected	Overall	Unaffected	Affected	Overall
SLH	κ=0.025 (0.130-0.180)	κ=0.109 (0.042-0.269)	-	ρ=0.293	ρ=0.632 **	-
COD	κ=0.056 (0.081-0.193)	κ=0.168 * (0.001-0.335)	-	ρ=-0.368 *	ρ=0.290	-
DVJ	κ=0.100 (0.025-0.224)	κ=0.270 (0.136-0.190)	κ=0.044 (0.123-0.211)	ρ=0.041	ρ=0.049	ρ=0.287

Values represent Cohen's Kappa (95% confidence interval) and Spearman's correlation
SLH single leg hop, COD change of direction, DVJ drop vertical jump, κ = Cohen's Kappa, ρ = Spearman's rho
Statistical significance denoted by * p<0.050, ** p<0.001

Assessor #1 and Assessor #2

An additional comparison of task-rated confidence of assessor #1 was completed using a second clinical assessor (Assessor #2). There was no agreement between confidence ratings for Assessor #1 and #2 for the SLH affected limb (κ=0.020, 95%CI= 0.160-0.200, p=0.816) and the unaffected limb (κ=0.172, 95%CI= 0.065-0.409, p=0.121), COD of the affected limb (κ=-0.071, 95% CI= 0.048-0.191, p=0.421), and the unaffected limb (κ=-0.119, 95%CI= -0.041-0.197, p=0.120), and for the DVJ both limbs (κ=0.077, 95%CI=0.168-0.322, p=0.385), affected limb (κ=0.020, 95% CI=0.105-0.145, p=0.771), and unaffected limb (κ=-0.060, 95%CI= 0.093-0.213, p=0.556).

Assessor #1 and #2 had fair-to-moderate correlations in ratings of confidence for the SLH of the affected limb (ρ=0.640, p=0.010) and the unaffected limb (ρ=0.528, p=0.045), COD of the affected limb (ρ=0.687, p=0.005) and unaffected limb (ρ=0.594, p=0.019), and for the

DVJ when rating both limbs (ρ =0.612, p=0.015) but a poor-to-fair correlation for the affected limb (ρ=0.225, p=0.420) and unaffected limb (ρ=0.330, p=0.230).

Agreement and correlation were also evaluated between assessor #2 and the participants. Full results displayed in Tables 9 and 10 which are attached to Appendix VIII.

Performance and Confidence Data

Affected Side Performance and Confidence Ratings (Participant and Assessor)

Fair correlations between the participant's confidence and performance of the affected limb for the SLH (ρ=0.470, p=0.007) and DVJ vGRF (ρ=0.376, p=0.034) were found, with minimal correlation for the COD (ρ=-0.200, p=0.271) and for DVJ height (ρ=0.229, p=0.207) (Table 7). There was a moderate correlation between the assessor's rating of confidence and absolute performance of the affected limb for the SLH (ρ=0.750, p<0.001) and the COD (ρ=-0.608, p<0.001), but a poor correlation for the DVJ vGRF (ρ=-0.108, p=0.558) and a fair correlation for DVJ jump height (ρ=0.342, p=0.056).

There was a fair correlation between the participant's affected limb confidence for the SLH LSI (ρ=0.567, p=0.001), but not the COD LSI (ρ=0.132, p=0.471) and DVJ vGRF LSI (ρ=0.293, p=0.104). Similarly, there was a moderate correlation between assessor confidence ratings of the affected side and SLH LSI (ρ=0.764, p<0.001), but not for the COD LSI (ρ=0.141, p=0.440) or DVJ vGRF LSI (ρ=-0.027, p=0.884).

Unaffected Side Performance and Confidence Ratings (Participant and Assessor)

Poor-to-fair correlations for the participant's unaffected limb confidence and performance in the SLH (ρ=0.301, p=0.094), COD (ρ=0.140, p=0.444), DVJ vGRF (ρ=-0.094, p=0.607), and DVJ jump height (ρ=0.035, p=0.851) were found. Moderate correlation between the assessor's confidence rating and performance of the unaffected limb for the SLH (ρ=0.639, p<0.001), and COD (ρ=-0.620, p<0.001) were found, while there was a fair correlation for DVJ jump height (ρ=0.420, p=0.017), but a poor degree of correlation for the DVJ vGRF (ρ=-0.206, p=0.258).

There were poor correlations between the participant's unaffected side confidence ratings and the SLH LSI (ρ=-0.076, p=0.678), COD LSI (ρ=0.216, p=0.234), and DVJ LSI (ρ=-0.057, p=0.758). Similar correlations were found between the assessor's unaffected side confidence ratings and SLH LSI (ρ=0.127, p=0.490), COD LSI (ρ=-0.103, p=0.575), and DVJ LSI (ρ=0.107, p=0.559).

Correlation to the ACL-RSI Questionnaire

ACL-RSI and Performance

There were fair-to-moderate correlations between the ACL-RSI score and affected limb performance for the SLH (ρ=0.558, p=0.001), COD (ρ=-0.643, p<0.001), and DVJ jump height (ρ=0.676, p<0.001), as well as for the unaffected side for the SLH (ρ=0.565, p<0.001), and COD (ρ=-0.627, p<0.001). There were no correlations between the ACL-RSI and the DVJ vGRF for the affected (ρ=0.080, p=0.661) or unaffected limb (ρ=0.153, p=0.403). Similarly, there was no correlation between the ACL-RSI and SLH LSI (ρ=0.167 p=0.360), COD LSI (ρ=0.127, p=0.490), or DVJ LSI (ρ=-0.029, p=0.877).

ACL-RSI and Confidence (Participant and Assessor ratings)

Fair correlations were seen between the ACL-RSI and the participant's confidence ratings of the affected limb for the SLH (ρ= 0.544, p=0.001), and the COD (ρ= 0.486, p=0.005), however, the DVJ correlation of similar magnitude did not achieve statistical significance (ρ= 0.346, p=0.052). There was a fair correlation between the ACL-RSI and the assessor's rating of confidence of the affected limb for the SLH (ρ= 0.365, p=0.040) and the COD (ρ= 0.519, p=0.002), but not for the DVJ (ρ= 0.196, p=0.283).

There was no correlation between the ACL-RSI and the participant's rating of confidence of the unaffected limb for the SLH (ρ= 0.198, p=0.227), COD (ρ= -0.074, p=0.686), and DVJ (ρ=-0.041, p=0.824). There was also no correlation between the ACL-RSI and the assessor's rating of confidence of the unaffected limb for the COD (ρ= 0.318, p=0.076) and the DVJ (ρ= 0.333, p=0.062), but there was a fair correlation for the SLH (ρ=0.428, p=0.015).

Figure 6 illustrates the correlations between the ACL-RSI, the participant's ratings of confidence, LSI, and absolute performance of the affected limb for the SLH when displayed as a scatterplot. The scatterplots (a, b, c, d) provide an individualized representation of the cohort compared to Table 7 which displays Spearman's rho and level of significance of the entire group. The SLH, in comparison to the other two tasks was depicted as it had the most consistent significant correlations to the ACL-RSI and ratings of confidence, as well as displaying a wide range of results which was representative of the study group.

Table 7. Overview of the correlations between performance, confidence, and the ACL-RSI

Task	LSI Performance + ACL-RSI	Absolute Performance + ACL-RSI	Confidence + ACL-RSI	Confidence + Absolute Performance
SLH	ρ=-0.029	ρ=0.558**	ρ=0.544**	ρ=0.470**
COD	ρ=0.127	ρ=-0.643**	ρ=-0.486*	ρ=0.200
DVJ	ρ=0.167	ρ=0.080	ρ=0.346	ρ=0.376*

Values represent Spearman's correlation (ρ = Spearman's rho), absolute performance is of the affected limb, and confidence ratings made by the participants
LSI limb symmetry index, ACL-RSI anterior cruciate ligament return to sport after injury, *SLH* single leg hop, COD change of direction, DVJ drop vertical jump
Statistical significance denoted by * p<0.050, ** p<0.001

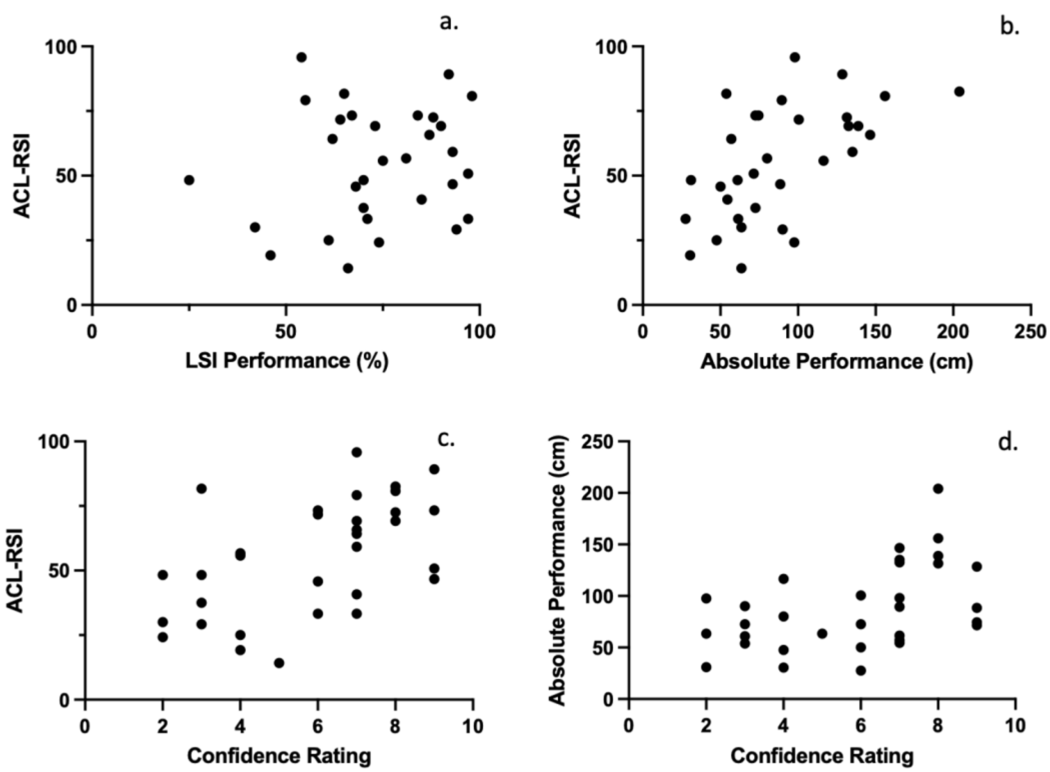

Figure 6. Scatterplot representation of correlations to single leg hop
(a.) Correlation between the ACL-RSI and SLH LSI performance (ρ=-0.029), (b.) correlation between the ACL-RSI and SLH absolute performance of the affected limb (ρ=0.558**), (c.) ACL-RSI and participant's confidence ratings of the affected limb for the SLH (ρ=0.544**), (d.) absolute performance participant's confidence ratings of the affected limb for the SLH (ρ=0.470**)
ACL-RSI anterior cruciate ligament return to sport after injury, *LSI* limb symmetry index, *SLH* single leg hop
Spearman's correlation (ρ = Spearman's rho), Statistical significance denoted by ** p<0.001

Participants with High Confidence Perform Better on SLH and have Higher ACL-RSI Score

Participants were divided into high (n=8) and low (n=24) groups based on their affected limb confidence ratings for the SLH. Participants in the high confidence group had superior absolute performance on their affected limb (mean performance of 124.16 ± 45.02 cm) compared to the low confidence group (mean performance 76.34± 33.13cm), 95%CI 17.58 to 78.04, $t(32) =-3.230$, $p=0.003$, $d=1.319$).

LSI of the SLH was higher in the high confidence group (91.08% ± 9.40) compared to the low confidence group (69.26 ± 17.52), 95%CI 8.48 to 35.16, $t(32) =-3.340$, $p=0.002$, $d =1.364$).

In addition, the high confidence group of participants had higher ACL-RSI scores (mean = 70.62 ± 14.97) compared to the low confidence group (mean = 50.07 ± 21.10), 95%CI 3.40 to 37.71, $t(32) =2.447$, $p=0.020$, $d =0.969$).

CHAPTER 4: DISCUSSION

The primary purpose of this study was to determine if a difference in task-specific confidence would be present between the unaffected and affected limbs of participants upon completion of three functional tasks at 6-months following ACLR. Secondary questions examined the degree of agreement and correlation between participant self-reported and assessor-rated confidence, and whether correlations would be found between confidence, absolute performance, LSI, and psychological readiness (ACL-RSI).

As hypothesized, our analysis revealed that confidence of the affected limb was rated lower than the unaffected limb across all three functional tasks, even when minimal performance differences were present (COD). The participants and the assessor may use differing schemas to rate confidence as little-to-no agreement or correlation was found between their ratings which was a contrast to our hypothesis where a low agreement, but moderate correlation was expected between ratings. In alignment with our hypothesis, fair-to-moderate correlations were present between confidence and absolute performance of the affected limb, suggesting participants with higher levels of confidence perform better on the functional tasks. Supporting what has recently been published in the literature[49,52,74], measures of psychological readiness and performance may depend on the metrics used, as correlations were found between the ACL-RSI and absolute affected limb performance, but not when performance was expressed as an LSI.

Without assuming directionality, these correlations suggest a relationship between confidence, absolute performance, and the ACL-RSI. Addressing confidence deficits throughout the rehabilitation process might prove to be beneficial as high confidence has been associated with superior performance and psychological readiness[1–3] and these constructs may have a positive impact on RTS rates.

Clarification of Confidence Terminology

Throughout the evolution of this thesis, it became evident that the terminology regarding confidence required clarification. Distinctions between general, overall, task-specific, and limb-specific confidence are thought to be necessary as these terms will be referred to often. For this thesis, general confidence refers to self-reported confidence assessed via PROM questionnaires, i.e., the KOOS questionnaire [Item #3: *How much are you troubled with lack of confidence in your knee?*] that is specific to the knees but not specific to limb or task. For this study, overall confidence refers to a rating of confidence that is not limb-specific but is task-specific (i.e., participants were asked to rate their confidence following the DVJ of both legs simultaneously), whereas Hart et al[5] utilized task-specific confidence to refer to a rating of confidence of a given task as assessed by VAS/NRS without specifying unaffected or affected side, and limb-specific confidence refers to a rating of confidence specific to the affected or unaffected limb following execution of a specific task.

Confidence Varies Between Limbs and Across Tasks

Confidence Varies by Limb

Prior studies using items from the KOOS, ACL-RSI, and confidence VAS have demonstrated that patients lack general knee confidence following ACLR[5,22,52,55], yet it was unknown if confidence would vary between limbs or tasks. Using the physical assessment protocol as an example, general physical function can be evaluated using self-reported measures of performance via PROMS (i.e., QOL, IKDC), but these questionnaires are typically accompanied with performance-based testing to assess physical function as well[75]. Traditionally, a combination of both unilateral and bilateral tasks are selected to allow for a comparison between the unaffected and affected limbs and for a comparison to normative data of healthy peers[8,37]. Assessing physical function by only using PROMS or bilateral performance tasks may inaccurately represent individual limb function because the results of both limbs can be amalgamated. Using similar assessment tools to assess overall measures of confidence (i.e., PROMS, KOOS or VAS) may also inaccurately represent confidence of the surgically reconstructed knee and thus the need for limb-specific evaluations of confidence.

Limb- and task-specific measures of confidence revealed that confidence was lower on the affected limb compared to the unaffected limb by the participants and the assessor for all three tasks. Although the clinical significance is unknown at this time, the median difference in confidence between limbs ranged from 2 to 4 units on the NRS by the participants, and from 1 to 3 units by the assessor across the three tasks. Published work using similar scales but differing constructs have suggested a difference of 1 to 2 units on an 11-item NRS as a minimally clinically significant difference (MCSD) when assessing pain[76] and mobility[77]. Webster et al[78] used the KOOS questionnaire as an external anchor criterion to determine the smallest detectable changes (SDC) and the minimally important changes (MIC) for the ACL-RSI to dichotomize patients from 6- to 12-mths timepoints, which may be a future option to explore with the metrics used in the present study (ACL-RSI against the confidence scale).

Future work is needed but identifying a difference in confidence between limbs following ACLR is a primary step in determining if ratings of confidence could be useful information for rehabilitative intervention and RTS decisions. While the significance of the between-limb difference is currently unknown, this may provide information regarding future restoration of knee function, RTS, or risk of re-injury.

Overall Confidence Differs from Limb-Specific Ratings of Confidence for the DVJ

Overall, unaffected, and affected limb confidence ratings were collected for the DVJ as it is a symmetric, bilateral task. Overall confidence varied from both the unaffected and affected limb-specific ratings of confidence. Participants rated confidence of their unaffected limb highest (median = 10/10), the affected limb lowest (6/10), and the overall rating in between the two limb-specific ratings (7/10). This suggests that overall ratings cannot accurately represent limb-specific ratings following a bilateral task because an overall rating may over-estimate psychological factors, specifically confidence, of the surgically reconstructed limb.

Similar arguments have been made in regard to LSI being used in place of absolute performance. LSI combines the performance of the unaffected and affected limbs into one overall value and this removes the ability to evaluate progress in performance or to compared to normative data[79]. Using absolute performance precisely evaluates how patients are performing in the moment and progressing overtime. It is thought reporting confidence in a similar fashion (limb-specific) may provide greater accuracy in the moment as well.

Confidence Varies by Task

Task specific confidence has rarely been investigated in the context of RTS and performance-based assessments[5]. It was unknown if the demands of the varying tasks would impact and alter the participant's confidence to complete the task, or if confidence was strictly limb-specific and not task-specific. The results revealed that the participants rated their affected limb confidence different between the COD and the DVJ, between the COD and the SLH, but not between the SLH and the DVJ as they were not significantly different from one another (Figure 5). Participants lacked the greatest amount of confidence during the SLH, followed by the DVJ, then the COD. This provides evidence that confidence is task specific as it varied between the hopping/jumping tasks (SLH and DVJ) and the acceleration/pivot task (COD).

This also supports the work of Bandura[80], Vealey et al[81], and Liew et al[82] who have stated that confidence is state dependent as it can change based on the circumstance. State confidence explains why an individual may feel confident kicking a soccer ball but not dribbling a soccer ball[1]. Or why a patient might feel confident to perform a task in a clinical setting (controlled environment) but lack the confidence to perform that same task on the field of play (uncontrolled environment). Varying tasks requires varying levels of skill, and each skill might impact confidence differently.

Identifying which tasks foster confidence and which erode confidence may be a useful tool to open a dialogue between rehabilitative specialists and patients. Although the physical literacy model is not directly utilized in rehabilitation, it does provide an optimistic theory that enhancing confidence via skill execution can lead to higher motivation to engage in activity[63,65,84]. Perhaps increased confidence could improve future RTS outcomes by incorporating the PL positive feedback cycle of confidence, competence, and motivation. It is believed that physical activity can be maintained by incorporating the PL model[85] and this might be a tool to improve the adoption/maintenance of activity following ACLR.

High Confidence is Correlated with Superior Performance

The optimal level of confidence to ensure success in sport is currently unknown and unfortunately recently published work presents mixed results. High levels of confidence have been sought after because this has been connected to better performance in sport and during RTS testing[5,22,53,56,81], but has also lead to an increased risk of subsequent injury[53].

Paterno and colleagues[53] used the KOOS-QOL questionnaire to evaluate general knee confidence and categorized their study cohort into two groups; high confidence and lacking confidence groups. They concluded that the high confidence group of ACLR patients were more likely to perform better during the RTS testing (PROMS, isokinetic strength testing, and hop tests) and were more likely to "pass" all the RTS testing criteria (LSI >90%). But these highly confident patients were also more likely to sustain a secondary ACL injury within 24 months of returning to sport when compared to patients lacking confidence (31.7% vs 16.2%).

To further evaluate the relationship between confidence and performance of this study population, the participants were dichotomized into high (confidence rating of ≥8/10, n=8) and low confidence (≤7/10, n=24) groups to test discriminant validity between groups for the SLH. The high confidence group hopped further, had a superior LSI (greater symmetry between limbs), and had higher ACL-RSI scores compared to the low confidence group. At 6-months post-ACLR typical SLH LSI values are reported to be around 70-75%[86] and ACL-RSI scores of 56[87,88]. However, the clinical criterion "passing" threshold (or cut-off values) to establish RTS clearance, as well as predict RTS at 2-years post-ACLR and reduce re-injury risk[17] have been set as a SLH LSI of 90% and an ACL-RSI score of ≥65 as an indicator of satisfactory recovery[36]. Based on this criterion, the high confidence group met the proposed cut-off values (mean SLH absolute performance= 124.16 ± 45.02cm, mean LSI = 91.08 ± 9.40%, mean ACL-RSI=70.62 ± 14.97), whereas the low confidence group did not "pass" the physical and psychological readiness criteria to RTS (mean SLH absolute performance= 76.34 ± 33.13cm, mean LSI = 69.26 ± 17.52%, mean ACL-RSI=50.07 ± 21.10). Alternatively, the minimal detectable change (MDC) for SLH LSI has been established as 8%[89] and the ACL-RSI as 19 points[90]. Although there is no timepoint comparison to make at this time, an unorthodox comparison between the high and low confidence groups based on the MDC values further emphasizes the between-group differences. A difference of 21.82% for the SLH LSI and 20.55 points for the ACL-RSI are seen between the groups exceeding the MDC threshold for these two measures.

At this time, a causal relationship cannot be assumed, it is unknown if increased confidence leads to better performance, or if better performance leads to increased confidence. But these results identify a potential relationship between task-specific confidence and absolute performance of the affected limb. Dichotomizing the participants by their confidence ratings presents a unique overview of how their recovery is advancing and in a clinical setting could provide insight on exercise prescription and progressions.

Confidence to be Used as an Additional Assessment Tool?

While large differences in absolute performance were collected for the SLH and DVJ between the unaffected and affected limbs, minimal differences were recorded for the COD (Table 4). This was an expected finding for the SLH and DVJ as performance differences post-ACLR have been well documented[8,91]. Conversely, the minimal differences in COD results were somewhat unexpected, but it should be noted that this is a common finding for completion times between limbs for COD type tasks[43,92,93]. Even in the presence of minimal differences in completion time, individuals may use differing movement strategies between limbs to execute this task. These differing strategies may manifest as reduced velocity of the center of mass when planting the affected limb, thereby reducing the demands on the affected limb while resulting in similar execution times[93]. Interestingly, King and colleagues[94] also suggested that differing completion strategies might be a result of reduced confidence of the affected limb. The consequence of adopting differing movement strategies post-ACLR is that it can increase the risk of re-injury[43,95]. Additionally, if time alone was used to evaluate performance one may conclude that symmetrical recovery had been achieved for the COD, whereas evaluating kinematic *and* kinetic data could reveal that as untrue.

The ability to collect kinematic and kinetic information depends on space/location, time, training, and resources to perform video and force plate analysis, a luxury many clinics do not have. Without biomechanical analysis, execution strategies and compensation deficits may go undetected resulting in a false evaluation of symmetric recovery. The rapid movements of COD may be more difficult to analyze relative to unilateral SLH, where differences in landing patterns may be more apparent without specialized technology. This may result in an inaccurate representation of the patient's performance and identifies the need for additional information in combination to completion time to evaluate performance of the COD. Having patients rate confidence during the COD may provide additional information about task completion when biomechanical analysis is unavailable.

Furthermore, the use of three functional tasks highlighted that successful task execution may occur at varying timepoints throughout rehabilitation as not all tasks recover simultaneously. As seen with the COD, movement strategies may be more difficult to quantify in a clinical setting at 6-months post-operatively without access to specialized equipment. Having patients rate their confidence might provide additional information regarding recovery for tasks where performance symmetry is restored early but differing movement strategies are still present. Alternatively, the SLH had highly detectable performance differences and therefore ratings of confidence might not be as impactful in the early stages of rehabilitation. Unilateral tasks like the SLH may take longer to recover so confidence may become more relevant at later timepoints when performance differences become minimal, but kinematics may have not yet recovered.

Varying movement strategies may be missed when absolute performance measurements are symmetrical. Therefore, ratings of confidence may add information beyond quantitative performance measures (time and distance) when measures of biomechanical outcomes cannot be collected. The evaluation of confidence is rapid to collect, inexpensive, and can easily be implemented into a clinical setting. However, future work is required to identify how confidence changes over time in relation to performance and kinematics.

Correlation between Confidence and Performance

While the present study may be the first to have participants rate limb- and task-specific confidence, Hart et al[5] used a similar approach where (overall) task-specific confidence was evaluated by having participants rate confidence on a VAS immediately following the completion of three SLH tasks (SLH for distance, cross-over hop, and side-to-side timed hop). Hart and colleagues[5] analyzed regressions and associations between task-specific confidence, absolute performance, and LSI of their chosen functional tasks at one-year post ACLR, but did not assess limb-specific confidence. They concluded that increased (overall) task-specific confidence was associated with better absolute performance and LSI for all functional tasks.

We on the other hand, using correlations saw a stronger relationship between task-specific confidence and absolute performance and a weaker correlation between task-specific confidence and LSI. Specifically, stronger correlations were present for the SLH and the DVJ where large differences in absolute performance and confidence were apparent. As a result of the minimal difference in completion times for the COD, absolute performance and confidence were not significantly correlated for this task.

Building upon the arguments of the previous section, this highlights an important finding that performance may not reflect confidence, and confidence may not reflect performance.

Although minimal differences in completion time were seen between limbs during the COD, with slightly faster times being completed on the affected limb, lower confidence was recorded for the affected limb. While a significant correlation was not present for the COD, both physical and psychological metrics are important when evaluating RTS. As seen with the COD, if completion time was used alone, one may conclude that an athlete is ready for sport when psychological readiness deficits may still be present.

The Importance of Performance Metrics in Relation to the ACL-RSI

The ACL-RSI has become a widely used questionnaire to gauge psychological readiness and inform and predict decisions about RTS[51,52]. A goal of the RTS battery is to determine the most appropriate functional tasks, PROMS, and metrics to make sound decisions about the patient's wellbeing to RTS and minimize the risk of re-injury[53]. Despite this, much of the work investigating correlations between physical performance and psychological readiness has focused on the ACL-RSI and performance expressed as an LSI. Evidence suggests that the metrics used, absolute performance versus LSI, influences the relationships between the ACL-RSI and performance. When assessing performance, utilizing LSI for RTS decisions can over-estimate knee function[79] due to the harvest of tissue from the contralateral leg, detraining of the unaffected limb, or neurologically-mediated bilateral effects of ACL injury[21] and remove the ability to compare performance to standardized normative data. The combination of tools selected to assess physical and psychological wellbeing is extremely important as this can determine the course of patient's return to activity[49]. When assessing performance, utilizing LSI for making RTS decisions can over-estimate knee function[79] and remove the ability to compare performance to standardized normative data. The combination of tools selected to assess physical and psychological wellbeing is extremely important as this can determine the course of patient's return to activity[49].

For the present study, no correlations between the ACL-RSI and performance when expressed as an LSI for the SLH, COD, or DVJ were found. Whereas when absolute performance of the affected limb was correlated with the ACL-RSI, fair-to-moderate correlations existed for the SLH, COD, and DVJ jump height but not for DVJ vGRF. This is consistent with the work of O'Connor et al[49] who also saw no-to-weak correlations between the ACL-RSI and LSI for single leg drop jumps and single leg counter movement jumps at 9-months post-ACLR. Similar findings but differing analysis was seen by Hart et al[5] who found statistically significant associations between absolute performance (SLH, cross-over hop, side to side timed hop) and the ACL-RSI but not between LSI and the ACL-RSI. Piussi et al[52] analyzed RTS passing cut-off rates looking at the correlations between the ACL-RSI, strength testing, and functional tasks (SLH) and although correlations were seen, the magnitude between the chosen tests greatly varied and they commented that a limitation of their study was using LSI in place of absolute performance. Conversely, Sonesson et al[74] found a poor correlation between the ACL-RSI and SLH LSI, but no other correlations for the remainder of their functional tasks (cross-over hop, triple hop, timed 6-meter hop, and SL squat test) and agreed that using LSI over absolute performance was a limitation of their study.

Cheney et al[96] theorized that the ACL-RSI *should* correlate with performance as psychological responses are anticipated following the ACL injury, surgery and rehabilitation. Whereas based on O'Connor's study results and the lack of a relationship between performance and the ACL-RSI[49], they suggested that psychological deficits should be assessed, but addressed separately from performance deficits as they may be different constructs. Absolute performance of the affected limb might be the more appropriate metric to use when evaluating correlations between the ACL-RSI because the affected limb is a probable source of psychological impact and lack of readiness to RTS. Our results would support Piussi et al[52] and Sonesson et al[74] theory that different metrics need to be explored to find correlations to the ACL-RSI.

Variable Correlations across Performance, Confidence, and the ACL-RSI

While under powered for the DVJ (p = 0.052, *post hoc* power = 0.504), fair correlations were present between the ACL-RSI and confidence ratings of the affected limb across all three tasks. This was not the case for affected limb confidence and absolute performance, or for absolute performance and the ACL-RSI where correlations were inconsistent across the three tasks (Table 7).

Given that confidence is a sub-domain of the ACL-RSI, it is interesting that a stronger correlation was present between the ACL-RSI and confidence for the DVJ (ρ=0.346) compared to the ACL-RSI and absolute performance for the DVJ (ρ=0.080). It is plausible that the weaker correlation between performance and the ACL-RSI is because the DVJ it is a bilateral task. In theory, participants were able to "assist" the movement of the DVJ with their unaffected limb as identified with the force plate analysis. Whereas the stronger correlation between confidence and the ACL-RSI may be a result of having participants rate either limb individually and removing their ability to rely on the unaffected limb to influence their rating. The combination of reduced confidence of the affected limb and psychological deficits, as indicated by the ACL-RSI (mean score = 50 ± 22), may be a reason why higher correlations were present for confidence but not performance for this task.

These findings support the literature suggesting that positive psychological readiness (ACL-RSI) and better performance are related[52], and that high confidence is related to superior performance[5,53]. Although directionality cannot be determined at this time, high confidence and better psychological readiness may also be related. The range of correlations across variables and tasks may also emphasize the importance of confidence as a PROM in addition to the ACL-RSI. Although confidence is a component of the ACL-RSI, it cannot be used interchangeably as both questionnaires provide diverse sources of information. Having patients complete the ACL-RSI also provides valuable information and has predictive potential of future RTS rates or risk of re-injury[5,54,55,97], but general measures of confidence may not guide rehabilitation in the same way as specific measures of confidence[82].

Participant's and Assessor's Rating of Confidence Do Not Agree

Although both the participants and the assessor rated task-specific confidence lower on the affected side compared to the unaffected side, raters may use differing schemas to rate confidence. There was low agreement between the participant's and the assessor's ratings of confidence for the SLH, COD, and DVJ on either limb and only the COD for the affected limb was statistically significant. Only a moderate correlation was seen for the SLH on the affected limb and a fair correlation for the COD on the unaffected limb (Table 6).

In addition to these ratings, a second assessor (Assessor #2) was recruited to evaluate inter-rater agreement and correlation with the primary assessor (Assessor #1) and to compare their ratings to the participants. Overall, agreement and correlation of the ratings of confidence between Assessor #2 and the participants were slightly lower compared to Assessor #1 and the participants. The lowest agreement, but highest correlation between raters was between Assessor #1 and Assessor #2 across all tasks. The slightly stronger agreement and correlation between Assessor #1 and the participants, compared to the other results could be a factor of the testing environment. Assessor #1, compared to Assessor #2, was present during the entirety of the research assessment and was able to observe all participant practice and familiarization trials during the testing battery. These factors may have influenced the assessor's perceptions of patient confidence which could be a result of the poor correlation and agreement between Assessor #2 and the participants ratings of confidence. Full results are displayed in Appendix VIII.

Traditionally stronger correlations and weaker agreements have been reported between clinician-rated measures and patient self-reports in studies evaluating general health and psychological factors such as depression[98,99]. Stronger agreement and correlation have been achieved when the clinician's ratings are expressed on a Likert scale and corresponded to a range of values on the patient's NRS, i.e. high confidence on the clinician's questionnaire would be equal to a participant rating of 10, 9, or 8 on their NRS[98]. However, Uher et al[99] suggested that perfect correlation and agreement may not be necessary as clinician and patient reports are not, and should not be interchangeable. Each rating can provide unique information and have differing purposes that are relevant to prognosis[99]. The patient's self-report measures their own perception of recovery/confidence[100], whereas the clinician's rating provides an external evaluation of how the patient is doing compared to their self-report. A lack of agreement and correlation is not a negative finding. Self-ratings and observer-ratings provide different but valuable information in a clinical setting[100].

Low agreement and correlation between the participant's and assessor's ratings of confidence may be a result of using different anchors to rate confidence. Participants might rate *absolute* confidence and index their unaffected limb in comparison to how the affected limb feels. Whereas the assessor may rate *relative* confidence and index participants to the highest levels of confidence observed across all subjects. The NRS also allows for an individualized interpretation of what each number on the scale means[77]. This can be both a strength and a downfall of the NRS because it allows for freedom of expression but defies anchors if not pre-defined. A rating of 5/10 can mean many different things to many different people, especially when self-reporting as past experiences regarding a task could greatly influence the rating.

To improve interrater agreement and correlation future work could explore pre-defined anchors, familiarization of the rating method, simplified schemas, and identical conditions between raters[101,102]. Various mixed methods studies could also provide a wealth of information through qualitative data collection. One study could include self-reported task-specific confidence ratings of participants followed by questionnaires to determine what lead to feelings of confidence or lack thereof. A second study could include interrater confidence evaluations between clinicians and feedback via questionnaire to explore what guided their ratings to expand and better inform the tentative criteria provided in Table 1 (Potential contributing factors of a clinician's perception of patient confidence) across varying tasks.

Clinical Relevance

It is well recognized that the psychological response to the ACL injury continues long after the injury has occurred and can have a negative impact on recovery and return to perform outcomes[82,103]. Although directionality is unknown, a correlation between performance, confidence, and the ACL-RSI has been identified. The ACL-RSI have been shown to be positively associated with RTS rates following ACLR and may have the ability to predict the likelihood of RTS at 12- and 24-months[5]. Given that confidence is a subdomain of the ACL-RSI and that correlations were present between task-specific confidence and the ACL-RSI, addressing confidence through rehabilitation might have an impact on overall psychological readiness. Building upon the work of PL, using positive and attainable challenges to build confidence may lead to increased motivation to remain engaged in sport/activity[85] which could positively influence RTS.

Piussi et al[52] were among the first to identify that utilizing both SLHs and psychological PROMs in place of extensive RTS batteries (i.e., multiple functional tasks and strength testing via isokinetic elevation) was an ideal combination to assess physical and psychological readiness to RTS. Based on the results of the present study, assessing confidence when clinical barriers such as time, space, and equipment may impede kinetic and kinematic analysis may also prove to be useful.

It remains unclear if physical and psychological readiness are independent of each other or if one directly influences the other. In either case, RTS batteries that solely assess physical function may not reflect the holistic recovery status of the patient.

Future Direction

This thesis was embedded into a longitudinal study which will continue to assess our study cohort at 12-, 24-, and 60-months post-operatively. Therefore, the ability to track and assess confidence long-term is a possibility. Future work can determine if ratings of confidence will change as participants progress through their recovery and if this will continue to be related to performance, the ACL-RSI, or future RTS rates and re-injury rates. With long-term data on a much larger study population (~n=298) the ability to run further analysis and regressions will be possible to add to and to support the current literature in this field, similar to the work completed by Hart and colleagues[5].

Due to the poor agreement and correlation were seen between participant and assessor ratings of confidence across the functional tasks. Performing a mixed methods study design would provide the opportunity for qualitative data collection asking participants and assessors to provide details as to why they rated confidence the way they did. This work could begin to build a definition of what “high” and “low” confidence is and/or resembles and how to assess and identify it. This could potentially lead to the development of a validated scale for assessing confidence.

Limitations

A limitation of this study is that there is not a task-specific confidence scale that has been previously validated in this population or context. We opted for an 11-point NRS, and following the thesis proposal Hart et al[5] published their work studying task-specific confidence utilizing a VAS. We were able to retrieve a wide range of confidence ratings and established that participants identified a difference in confidence between limbs and across tasks, but our chosen scale may have resulted in our poor inter-rater correlation and agreement results. The literature suggests using a Likert-type scale with >3 but <7 responses and no ambiguity to increase the likelihood of correlation and agreement across raters[101]. It is believed that the NRS was the appropriate scale for participants to rate their perceived confidence, but perhaps a simplified Likert could be introduced to assess inter-rater reliability between clinicians.

While preliminary evidence suggest task-specific confidence correlates with related patient-reported measures, and discriminant validity has been established with both performance and the ACL-RSI, the same cannot be said for assessor’s ratings of perceived participant confidence. Future study with numerous clinicians of differing clinical backgrounds and experience levels viewing patients of differing confidence levels is required to validate the use of this additional outcome.

Another limitation of this study is that the Assessor #1 was not blinded to the surgically reconstructed limb of the participants. Without knowing it, this may have introduced an element of bias in their confidence ratings. Assessor #1 and Assessor #2 also had access to different information based on the environment which may have influenced the assessor's ratings of confidence. Assessor #1 was in the lab during the entire research assessment and was present as the participants were familiarized with the functional tasks and saw if any failed attempts were performed. Assessor #2 did not have access to this information, they only saw the video recordings of the trials that were successful and recorded as complete.

CHAPTER 5: CONCLUSION

Suboptimal RTS rates have led to the realization that physical ability and psychological barriers may have a significant impact on an athlete's decision and ability to return to sport[10,82]. This emphasizes the importance of a multifaceted rehabilitative approach that addresses all areas of healing and recovery. Physical recovery and psychological readiness may occur at varying rates following ACLR, but both are important for a successful return to an active lifestyle[97]. Knee confidence, a subdomain of psychological readiness, has been reported to have the greatest influence on those who RTS[82]. The current study demonstrated that confidence can vary between limbs and across tasks even when little difference in performance is evident (as seen with the COD task). Correlations between task-specific confidence and absolute performance were evident, as well as correlations between task-specific confidence and the ACL-RSI. Although direction cannot be assumed at this time, discriminant validity identified that participants with higher confidence performed better on the SLH and had higher scores on the ACL-RSI.

It is possible to "pass" physical testing but fail psychological readiness cut-offs resulting in an athlete who might not be ready to RTS[52]. Rehabilitative specialists therefore need the tools to evaluate both constructs within the clinical setting to gain appropriate information about the holistic wellbeing of the patients under their carer. Confidence, being modifiable and related to performance and psychological readiness may be a relevant tool to help guide rehabilitative intervention, progressions, and decisions regarding RTS.

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APPENDICES

Appendix I: REB amendment request and approval

Date Received

University of Manitoba

Request for Amendment /Changes to the Previously Approved Study
Research Ethics - Bannatyne

PI Last Name	MacDonald	HS Number	19878	H/B Number	B2016:066

Checklist of Requirements for Amendments

1. This amendment requires FULL BOARD Review. I have reviewed the website for Submission Deadline Dates and the Checklist for FULL BOARD REVIEW Amendments and verify that I have included the required documents. ☐ Yes ☑ N/A
2. This amendment requires DELEGATED REVIEW. I have reviewed the Checklist for DELEGATED REVIEW for Amendment and verify that I have included the required documents. There is no submission deadline if it qualifies for delegated review. ☑ Yes ☐ N/A Full Board review
3. Clinical Trial Registration Update (if applicable) NOTE: If you are the lead investigator you must update the Clinical Trial Registry record promptly with all changes and also verify the record status on the Registry at a minimum every 6 months to ensure publication of the study data will be accepted at a later date.
   I confirm that the Clinical Trial Registry Record relating to this study has been updated with any modification/ amendments. The record has also been verified/updated at this time to indicate the current recruitment and study status.
   ☑ Yes
   ☐ N/A I am not the Lead Investigator of this multi-centre study
   ☐ N/A this is not a clinical trial that required Clinical Trial Registration

1. Date of Report	2. Ethics File Number	3. Sponsor Protocol Number	4. Sponsor/Funder
July 13, 2020	B2016:066	n/a	Pan Am Clinic Foundation

5. Study/Project Title (or Registry/ Biobank Name, etc.)

Number one overall graft pick? Hamstring vs Bone-Patellar-Tendon-Bone vs Quadriceps Tendon: A Prospective Cohort Study

6. Principal Investigator(s) or Student Principal Investigator (PI) or Supervisor of Student PI (A change in PI must be reported to Change in Personnel Amendment Form) (Click + to add or delete rows to the table)

Name	Position
Peter MacDonald	Principal Investigator

Please review the guidelines Submission and Review Procedures for Amendment/Changes to the Previously Approved Study to determine whether delegated or full board review is required.

7. Delegated or Full Board Review

☑ **Delegated Review**

Provide rationale why delegated review is being requested. If it is determined by the Chair that your amendment requires full board review you will be contacted to provide the additional copies of relevant documents.

There is no additional risk to participants introduced in this amendment as the changes are primarily administrative.
We would like to add one co-investigator to the study and are updating our current forms and consent letter to reflect that. We would also like to add two forms to the study, 1. x-ray reading form and 2. a questionnaire for the participant to complete during follow up visits.

☐ **Full Board Review**

Request for Amendment /Changes to the Previously Approved Study Page 1 of 1

Research Ethics Bannatyne
P126-770 Bannatyne Avenue
Winnipeg, MB R3E 0W3
T: 204 789 3255
F: 204 789 3414
bannreb@umanitoba.ca

University of Manitoba | Research Ethics and Compliance

BIOMEDICAL RESEARCH ETHICS BOARD (BREB)

CERTIFICATE OF FINAL APPROVAL FOR AMENDMENTS AND ADDENDUMS

PRINCIPAL INVESTIGATOR: Dr. Peter MacDonald	**INSTITUTION/DEPARTMENT:** U of M and Pan Am Clinic Foundation/Medicine/Orthopedic Surgery	**ETHICS #:** HS19878 (B2016:066)
BREB MEETING DATE (if applicable):	**APPROVAL DATE:** July 16, 2020	
STUDENT PRINCIPAL INVESTIGATOR SUPERVISOR (if applicable): NA		

PROTOCOL NUMBER: NA	**PROJECT OR PROTOCOL TITLE:** Number one overall graft pick? Hamstring versus Bone-Patellar Tendon-Bone Quadriceps Tendon: A Prospective Control Study
SPONSORING AGENCIES AND/OR COORDINATING GROUPS: Alexander Gibson Fund and Pan Am Clinic Foundation	

REMINDER: **THE CURRENT BREB APPROVAL FOR THIS STUDY EXPIRES:** **June 27, 2021**

REVIEW CATEGORY OF AMENDMENT:	**Full Board Review** ☐	**Delegated Review** ☒
Submission Date of Investigator Documents: July 13, 2020	**BREB receipt date of Documents:** July 15, 2020 (Email)	

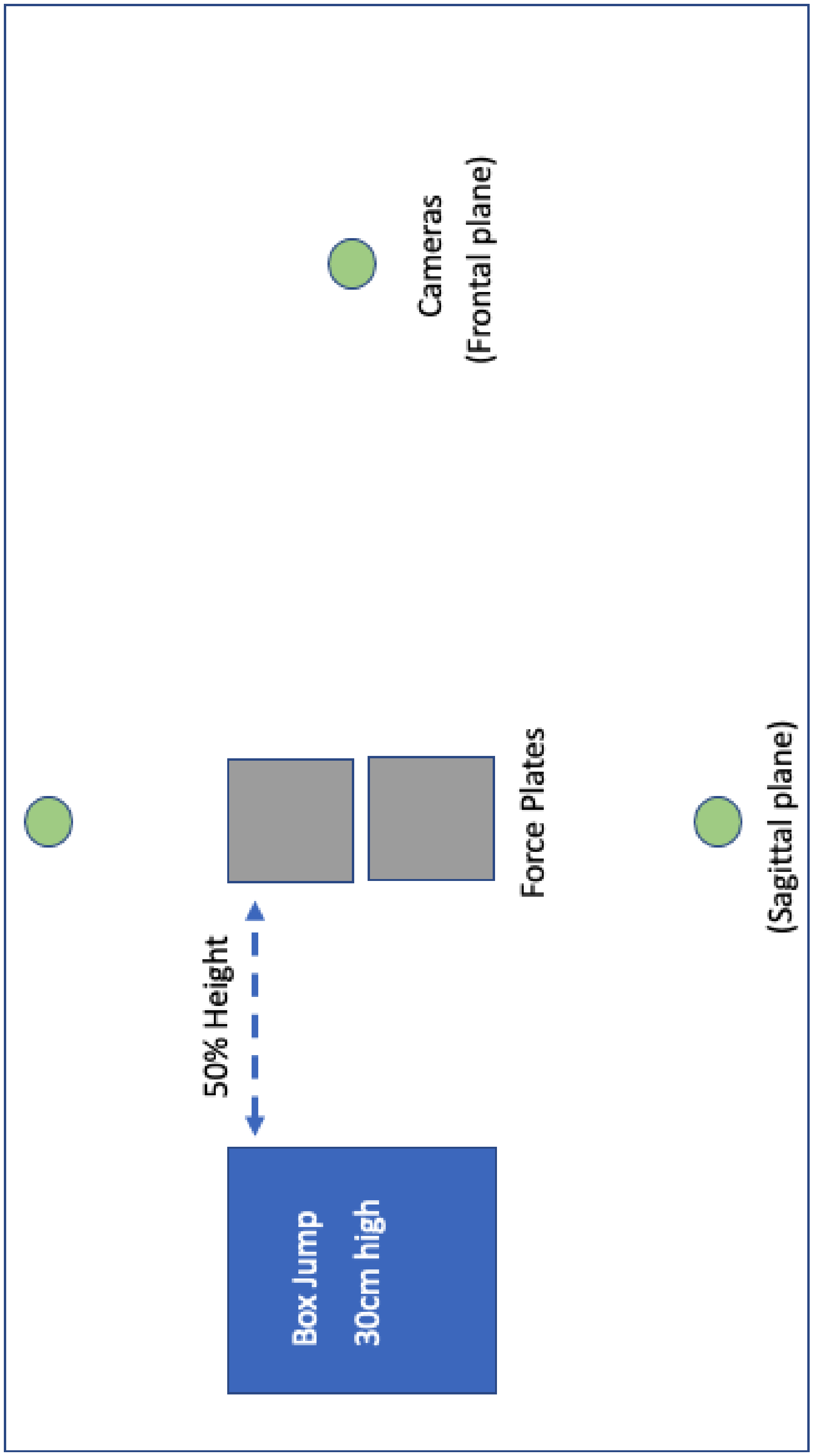
THE FOLLOWING AMENDMENT(S) and DOCUMENTS ARE APPROVED FOR USE:

Document Name	Version(if applicable)	Date
Protocol:		
Protocol	V. 6.0	July 13, 2020
Consent and Assent Form(s):		
Research Participant Information and Consent Form		15 JUNE 2020
Other:		
Questionnaires/Scales/Instruments Appendix		15-July-2020

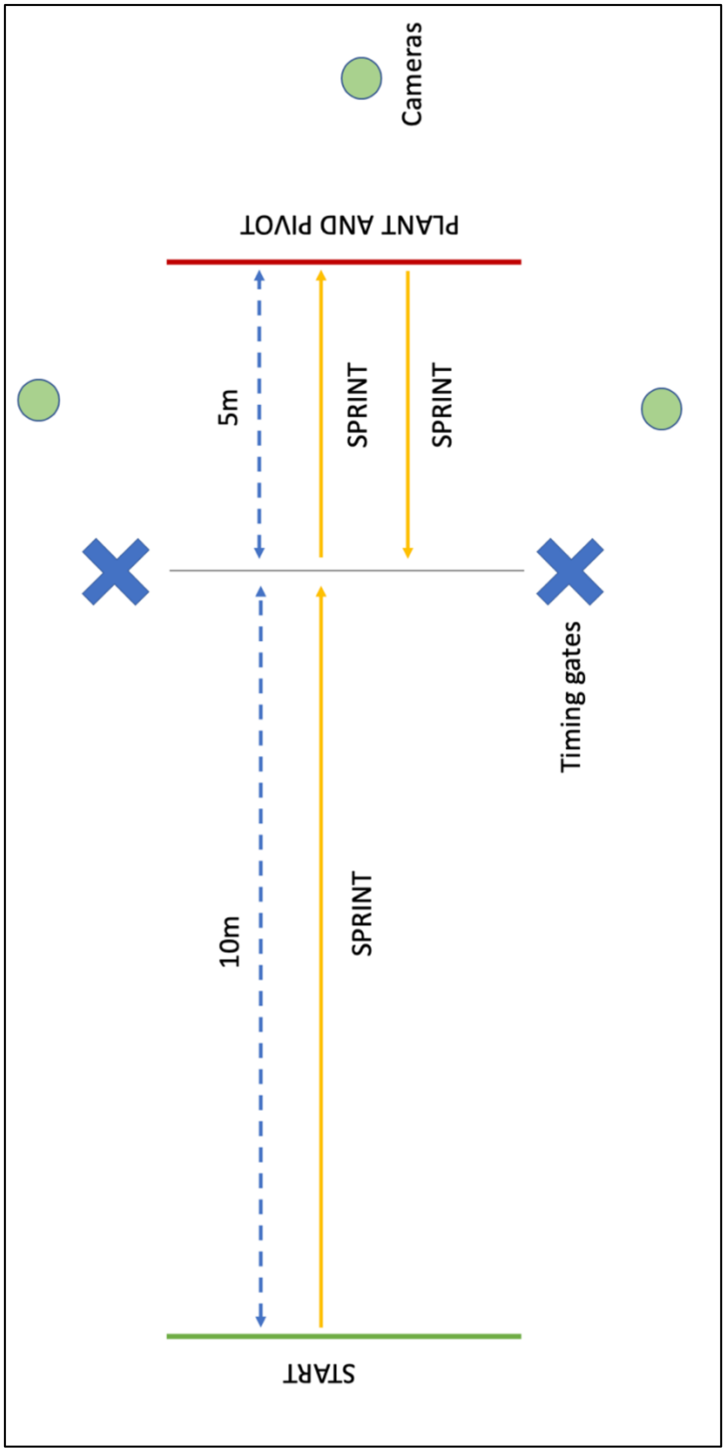
CERTIFICATION
The University of Manitoba (UM) Biomedical Research Board (BREB) has reviewed the amendment to the research study/project named on this ***Certificate of Approval*** as per the category of review listed above and was found to be acceptable on ethical grounds for research involving human participants. The amendment and documents listed above were granted final approval by the Chair or Acting Chair, UM BREB.

BREB ATTESTATION
The University of Manitoba (UM) Biomedical Research Board (BREB) is organized and operates according to Health Canada/ICH Good Clinical Practices, Tri-Council Policy Statement 2, and the applicable laws and regulation of Manitoba.

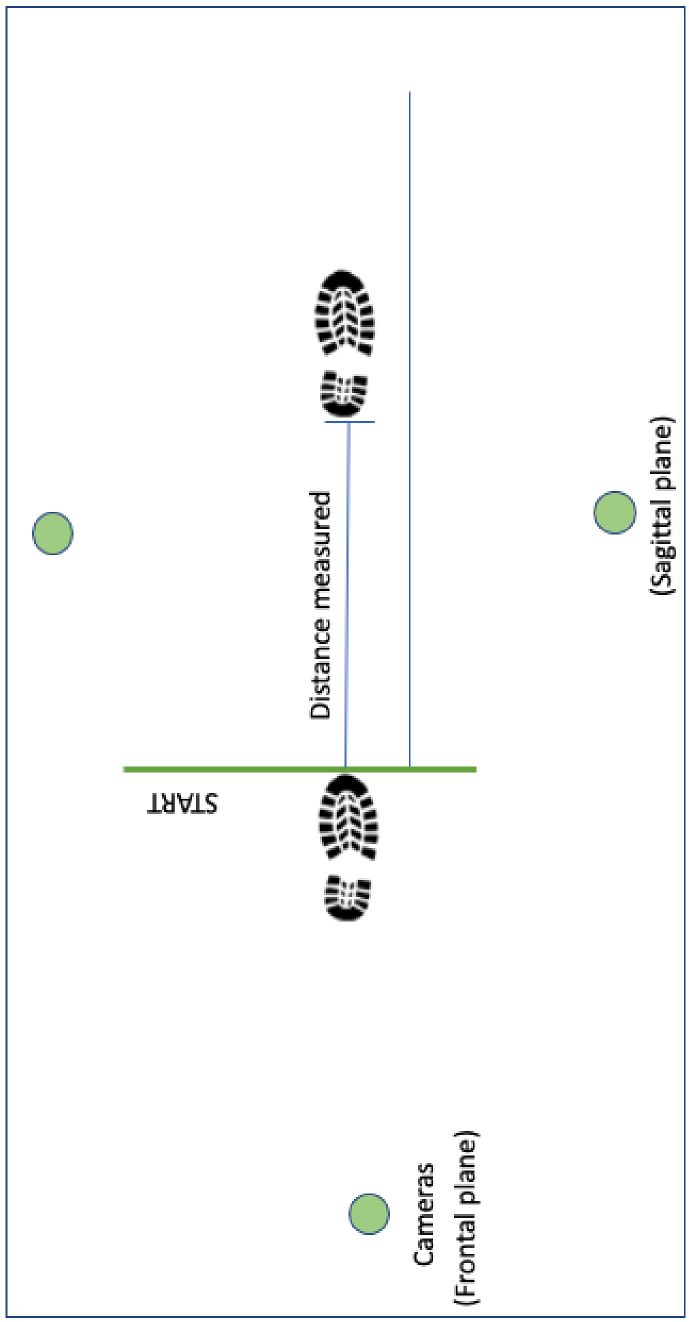
Appendix II: DVJ layout



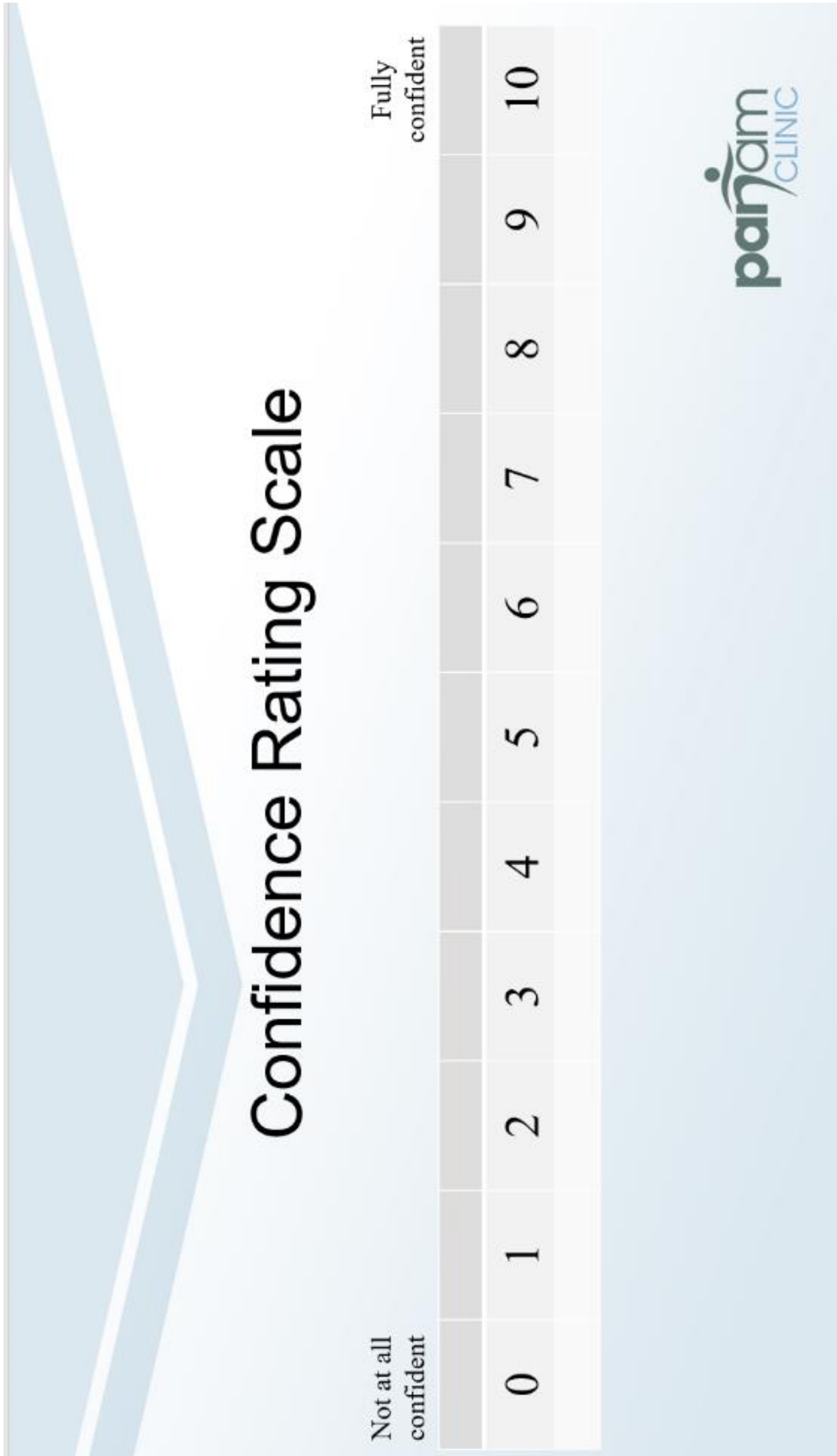
Appendix III: COD layout



Appendix IV: SLH layout



Appendix V: Confidence NRS



Appendix VI: ACL-RSI Questionnaire

panam CLINIC FOUNDATION INC.

Study ID: ______________________

Date: ______________________

Visit: ☐ 6mths ☐ 12mths ☐ 24mths ☐ 36mths ☐48mths ☐ 60mths

ACL GC: ACL RETURN TO SPORT & INJURY (ACL-RSI)

Instructions: Check the box that best describes you in relation to the descriptors.

1. Are you confident that you can perform at your previous level of sport participation?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Fully confident

2. Do you think you are likely to re-injure your knee by participating in your sport?

Extremely likely	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Not likely

3. Are you nervous about playing your sport?

Extremely	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Not at all

4. Are you confident that your knee will NOT give way by playing your sport?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Fully confident

5. Are you confident that you could play your sport without concern for your knee?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Fully confident

6. Do you find it frustrating to have to consider (think about) your knee with respect to your sport?

Extremely frustrating	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Not at all

7. Are you fearful of re-injuring your knee by playing your sport?

Extremely	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Not at all

Version 1.0 13-July-2020 Page 1 of 2

PanAm Clinic Foundation Inc.

Study ID: ____________________________
Date: ____________________________
Visit: ☐ 6mths ☐ 12mths ☐ 24mths ☐ 36mths ☐48mths ☐ 60mths

8. Are you confident about your knee holding up under pressure?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Fully confident

9. Are you afraid of accidently injuring your knee by playing your sport?

Extremely	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Not at all

10. Do thoughts of having to go through surgery and rehabilitation prevent you from playing your sport?

All of the time	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	None of the time

11. Are you confident about your ability to perform well at your sport?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Fully confident

12. Do you feel relaxed about playing your sport?

Not at all	☐ 0	☐ 10	☐ 20	☐ 30	☐ 40	☐ 50	☐ 60	☐ 70	☐ 80	☐ 90	☐ 100	Extremely

ACL-RSI (Total x 100)/120 = ___________%

Appendix VII: Data recording sheet

Study ID: ________________________________

ASSESSOR #1 CONFIDENCE FORM - ACL GRAFT STUDY

Date: (d/m/y) ____________________ **Interval:** ☐6M[3] ☐12M[4] ☐24M[5] | **Affected side:** ☐ Left ☐ Right

BOTH LEGS: On a scale of zero to ten, zero being no confidence and ten being fully confident, would you be able to rate your confidence while performing the 3 drop vertical jumps?
INDIVIDUAL: Using that same scale, would you be able to rate just your non-surgical side? And would you be able to rate your surgical side?

Height: ________________________________ Weight: ________________________________
Plate Weight: ____________________________

DROP JUMP *	Side (L or R)	Patient's Confidence (BOTH)	Patient's Confidence (INDIV.)	Unable to Perform
DVJ Unaffected				☐
DVJ Affected				☐

5-0-5 *

	Side (L or R)	Trial 1 (sec)	Trial 2 (sec)	Patient's Confidence	Unable to Perform
Plant unaffected					☐
Plant affected					☐

Single Leg Hops

		Trial 1 (cm)	Trial 2 (cm	Patient's Confidence	Unable to Perform
Single Hop for Distance *	**Unaffected**				☐
	Affected				☐
Triple Hop	**Unaffected**				☐
	Affected				☐
Crossover Hop *	**Unaffected**				☐
	Affected				☐
Timed Hop	**Unaffected**				☐
	Affected				☐

* RECORD WITH CAMERA

Version 1 (19-Jan-21)

Appendix VIII: Second Rating of Confidence

To evaluate inter-rater reliability, a second assessor (Assessor #2) was recruited to rate the perceived confidence of the participants to be compared to the first assessor's (Assessor #1) ratings of confidence. Assessor #2 rated confidence via video analysis of 15 randomly selected study participants. To establish consistency and similarity between the two assessors and the rating conditions, Assessor #2 was selected based on their professional background (certified Athletic Therapist) and familiarity assessing patients following ACLR. Assessor #2 was given Table 1 (Contributing Factors of Perception of Confidence), the confidence NRS, and a brief instructional video example before beginning his ratings of confidence. Comparable to Assessor #1, Assessor #2 was blinded to the participant's ratings of confidence, but was given the participant's age, sex, graft type, treating surgeon, and surgical limb side. The order that Assessor #2 reviewed the functional tasks for rating was consistent with the live assessment. Assessor #2 was instructed to watch each video clip once, without pausing or stopping the task to mirror the live assessment.

Results

Assessor #2 and the Participants – Agreement and Correlation

There was no agreement of the confidence ratings between Assessor #2 and the participants for the SLH affected limb (κ=-0.019, 95%CI=0.108-0.146, p=0.788) or the unaffected limb (κ=0.022, 95% CI=0.294-0.338, p=0.871), for the COD affected limb (κ=0.071, 95% CI=0.082-0.224, p=0.239), and the unaffected limb (κ=0.000, and statistical significance was not computed by SPSS, and for the DVJ confidence rating of both limbs (κ=-0.066, 95%CI=0.056-0.188, p=0.439) and of the unaffected limb (κ=0.052, 95%CI=0.177-

0.281, p=0.674), but there was minimal agreement for affected limb (κ=-0.166, 95%CI=0.056-0.276, p=0.043).

Assessor #2 and the participants had poor-to-fair correlations between their ratings of confidence for all of the functional tasks across both limbs, SLH of the affected limb (ρ=0.400, p=0.139), unaffected limb (ρ=-0.103, p=0.716), COD of the affected limb (ρ=0.257, p=0.355), unaffected limb (ρ=0.018, p=0.949), DVJ rating for both limbs together (ρ=0.197, p=0.481), affected limb (ρ=0.467, p=0.079) or unaffected limb (ρ=-0.021, p=0.942).

Assessor #1 and Assessor #2 – Agreement and Correlation

There was no agreement between confidence ratings for assessor #1 and #2 for the SLH affected limb (κ=0.020, 95%CI= 0.160-0.200, p=0.816) and the unaffected limb (κ=0.172, 95%CI= 0.065-0.409, p=0.121), COD of the affected limb (κ=-0.071, 95% CI= 0.048-0.191, p=0.421), and the unaffected limb (κ=-0.119, 95%CI= -0.041-0.197, p=0.120), and for the DVJ both limbs (κ=0.077, 95%CI=0.168-0.322, p=0.385), affected limb (κ=0.020, 95% CI=0.105-0.145, p=0.771), and unaffected limb (κ=-0.060, 95%CI= 0.093-0.213, p=0.556).

Assessor #1 and #2 had fair-to-moderate correlations in ratings of confidence for the SLH of the affected limb (ρ=0.640, p=0.010) and the unaffected limb (ρ=0.528, p=0.045), COD of the affected limb (ρ=0.687, p=0.005) and unaffected limb (ρ=0.594, p=0.019), and for the DVJ when rating both limbs (ρ =0.612, p=0.015) but a poor-to-fair correlation for the affected limb (ρ=0.225, p=0.420) and unaffected limb (ρ=0.330, p=0.230). All results displayed in Tables 9 and 10.

Summary

Overall, the agreement of the ratings of confidence between Assessor #2 and the participants was slightly lower compared to Assessor #1 and the participants. The only statistically significant result was between the ratings of confidence for the affected limb for the DVJ. The lowest agreement between raters was between Assessor #1 and Assessor #2 across all tasks, including some negative values indicating that the agreement between the two raters was less than the agreement expected by chance (-1 would indicate that there was no observed agreement, i.e., raters did not agree on anything). Compared to the minimal agreement results, fair-to-moderate correlations were present between all of the raters. Correlations between Assessor #1 and the participants were slightly stronger compared to the results between Assessor #2 and the participants, and between Assessor #1 and #2.

The stronger agreement and correlation between Assessor #1 and the participants, compared to the other results might be a factor of the testing environment, which was outlined in the limitations section above. Assessor #1, compared to Assessor #2 was in the lab during the entirety of the research assessment and was able to observe all practice and familiarization trials during the testing battery. These factors may influence the assessor's perceptions of patient confidence which could be a result of the poor correlation and agreement between Assessor #2 and the participants ratings of confidence.

The poor results between Assessor #1 and Assessor #2 emphasizes the diversity of how confidence presents itself and how an external observer perceives confidence. Additional work is needed to build a consensus of what high versus low levels of confidence is and how that should be evaluated in a clinical setting. The need to identify desirable and risky confidence characteristics may also be of relevance and how that spectrum may align with high and low ratings.

Table 8. Agreement of confidence ratings between the assessors and the participants

	Assessor #1 + Participants			Assessor #2 + Participants			Assessor #1 + Assessor #2		
	Unaffected	**Affected**	**Overall**	**Unaffected**	**Affected**	**Overall**	**Unaffected**	**Affected**	**Overall**
SLH	κ=0.025 (0.130-0.180)	κ=0.109 (0.042-0.269)	-	κ=0.022 (0.294-0.338)	κ =-0.019 (0.108-0.146)	-	κ=0.172 (0.065-0.409)	κ=0.020 (0.160-0.200)	-
COD	κ=0.056 (0.081-0.193)	κ=0.168 * (0.001-0.335)	-	κ=0.000	κ=0.071 (0.082-0.224)	-	κ=-0.119 (-0.041-0.197)	κ=-0.071 (0.048-0.191)	-
DVJ	κ=0.100 (0.025-0.224)	κ=0.270 (0.136-0.190)	κ=0.044 (0.123-0.211)	κ=0.052 (0.177-0.281)	κ=-0.166* (0.056-0.276)	κ=-0.066 (0.056-0.188)	κ=-0.060 (0.093-0.213)	κ=0.020 (0.105-0.145)	κ=0.077 (0.168-0.322)

Values represent Cohen's Kappa (95% confidence interval)
SLH single leg hop, COD change of direction, DVJ drop vertical jump, κ = Cohen's Kappa, statistical significance denoted by * p<0.050, ** p<0.001

Table 9. Correlation of confidence ratings between the assessors and the participants

	Assessor #1 + Participants			Assessor #2 + Participants			Assessor #1 + Assessor #2		
	Unaffected	**Affected**	**Overall**	**Unaffected**	**Affected**	**Overall**	**Unaffected**	**Affected**	**Overall**
SLH	ρ=0.293	ρ=0.632 **	-	ρ=-0.103	ρ=0.400	-	ρ=0.528*	ρ=0.640*	-
COD	ρ=-0.368 *	ρ=0.290	-	ρ=0.018	ρ=0.257	-	ρ=0.594*	ρ=0.687*	-
DVJ	ρ=0.041	ρ=0.049	ρ=0.287	ρ=-0.021	ρ=0.467	ρ=0.197	ρ=0.330	ρ=0.225	ρ =0.612*

Correlation determined by Spearman's rank order, ρ = Spearman's rho, statistical significance denoted by * p<0.050, ** p<0.001