RETURN TO SPORT FOLLOWING ACL RECONSTRUCTION

DETERMINATION OF SUCCESSFUL RETURN TO SPORT FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A NATION-WIDE SURVEY

By JACQUIE MINNES, BSc.PT., B.P.E.

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TITLE: Determination of Successful Return to Sport Following Anterior Cruciate Ligament Reconstruction: a Nation-Wide Survey

AUTHOR: Jacquie Minnes, B.Sc.P.T. (University of Toronto), B.P.E. (University of Western Ontario).

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ABSTRACT

Objective: To perform an environmental survey of clinical practice amongst surgeons and physiotherapists in making return to sport (RTS) decisions following ACL reconstruction (ACLR); to gain a better understanding of how clinicians and patients define successful return to sport; and to compare patients' level of satisfaction with their current level of activity following ACLR.

Design: Multidisciplinary cross sectional study.

Setting: Online

Participants: Orthopaedic surgeons and registered physiotherapists; and patients who had undergone ACLR within the previous 6-18 months.

Interventions: Surgeons and physiotherapists completed separate web surveys, each consisting of 10 closed format questions that included sections on demographics, outcome measures, treatment procedures, and RTS decisions. Patients completed a web survey consisting of 19 questions about their activity level, their experience surrounding the process of rehabilitation after ACLR, and their decisions surrounding RTS.

Main Outcome Measures: Descriptive and subjective data were collected for all groups. Clinician responses were compared for differences in frequencies of clinical outcome measures used to decide RTS readiness. Frequency data were collected for all groups for the definition of successful RTS following ACLR using a self-report form. The relationship between patient satisfaction and current level of activity following ACLR was compared using the Tegner Activity Scale and Single Assessment Numeric Evaluation (SANE).

Results: All patients were unanimous in their definition of successful RTS post ACLR as the ability to fully participate in pre-injury level of sport with no limitations or deficits (100%), and restoring functional stability (100%). Mean Tegner activity level scores of respondents decreased a mean of 3.4 (SD ± 2.5) from pre-injury to current level of activity ($p < 0.011$). However, no significant decrease from pre-injury level of activity to expected level of activity post surgery was seen. A statistically significant correlation was demonstrated between patients' level of satisfaction and current level of activity ($r = 0.84$, $p = 0.02$), with higher levels of activity associated with increased levels of satisfaction. Overall, the majority of clinician respondents reported that jump tests, range of motion (ROM), Lachman clinical test of stability, pain, swelling, functional movement and giving way contributed to their RTS decisions. Unanimous consensus existed between clinicians for the ability to participate in any level of sport, with or without limitations, as the definition of successful RTS following ACLR.

Conclusions: Following ACLR, medically cleared patients had not met their high expectations of functional stability and ability to return to their pre-injury level of sport. The discordance between unmet expectations and current level of sporting activity was reflected in lower rates of patient satisfaction. Most clinicians reported using primarily impairment based not self-report measures to contribute to their RTS decisions. Clinicians and patients expressed subtle differences in their definition of successful RTS.

Clinical Relevance: Establishing an operational definition of success, and professional consensus on measures which include patient reported outcomes is an important next step in the development of goal oriented RTS guidelines.

Key Words: ACL reconstruction, knee injury, return to sport, outcome measure

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DECLARATION OF ACADEMIC ACHIEVEMENT

Jacquie Minnes contributed to all aspects of this manuscript, including development of research questions, formulating the study design and web surveys, completion and submission of the ethics proposal, contacted the Canadian Physiotherapy Association for help in distributing the survey to physiotherapists, coordinated distribution of the physician survey with the Canadian Orthopaedic Association, contacted the participating National Sporting Organizations for patient recruitment, and posted patient recruitment invitations on sports injury blog web sites, completed the data collection, analyzed all the data, and prepared the manuscript in its entirety. Joy MacDermid assisted in refining the research questions and provided editorial assistance in the final manuscript preparation. Dr. Lucas Murnaghan assisted in the initial refinement of question development, and provided assistance with establishing the study's relationship with the Canadian Orthopaedic Association.

TABLE OF CONTENTS

LIST OF TABLES

LISTS OF FIGURES

Page

APPENDICES

LISTS OF ALL ABBREVIATIONS AND SYMBOLS

ACL	Anterior Cruciate Ligament
ACLR	Anterior Cruciate Ligament Reconstruction
ACL-RSI	Anterior Cruciate Ligament -Return to Sport Index
ADLs	Activities of Daily Living
AGM	Annual General Meeting
A-P laxity	Anterior-Posterior Knee Laxity
BPTB	Bone-patellar tendon-bone
CI	Confidence Interval
CKRS	Cincinnati Knee Rating Scale
COA	Canadian Orthopaedic Association
CPA	Canadian Physiotherapy Association
GKRS	Global Knee Rating Scale
HT	Hamstring Tendon
ICC	Intraclass Correlation Coefficient
ICF	International Classification of Functioning, Disability, and Health
IKDC	International Knee Documentation Committee
IOC	International Olympic Committee
KOOS	Knee Injury and Osteoarthritis Outcome Score
KRQoL	KRQoL
LCL	Lateral Collateral Ligament

LEFS	Lower Extremity Functional Scale
MCID	Minimal Clinically Important Difference
MCL	Medial Collateral Ligament
MDC	Minimal Detectable Change
MOON	Multicentre Orthopaedic Outcomes Network
OA	Osteoarthritis
PRO	Patient Reported Outcome
R-ACLR	Revision Anterior Cruciate Ligament Reconstruction
ROM	Range of Motion
RTP	Return to Play
RTS	Return to Sport
SANE	Single Assessment Numeric Evaluation
SEM	Standard Error of Measurement
SF-36	Short Form-36
TSK	Tampa Scale for Kinesiophobia
WHO	World Health Organization

CHAPTER I

INTRODUCTION

1.1 Historical Perspective

Anterior cruciate ligament (ACL) injuries are among the most common sporting injuries of the knee. As the primary stabilizing ligament of the knee, the ACL has an important role in maintaining stability of the knee during cutting, pivoting, and deceleration activities. Anterior cruciate ligament reconstruction (ACLR) continues to be the standard of care for patients wishing to resume athletic participation following an ACL rupture. With advances in surgical techniques and evidence based rehabilitation comes the expectation by patients that they can resume their previous level of sporting activity following ACLR. Historically, return to sport (RTS) decisions have been based on a combination of chronological and clinical outcome measures according to individual surgeons' protocols. Currently, no clinical practice guidelines exist to determine the appropriate and timely release of patients post ACLR to athletic activities.

While primary ACLR is increasingly commonplace, evidence suggests that clinical outcomes following revision ACLR are less favourable. The emotional, physical, and time investment by the patient into postsurgical recovery and rehabilitation after primary ACLR is significant, often driven by high expectations of resumption of pre-injury activity levels (Wright et al., 2012). The need to endure a revision ACLR and the associated post-surgical morbidity after graft failure is a traumatic outcome for patients. In a systematic review and meta-analysis of 21studies with a minimum of 2 year follow-up, Wright et al. (2012) tested the hypothesis that revision ACLR results in inferior outcomes. A pooled analysis was performed, comparing results of the meta-analysis with previously reported outcomes from large prospective studies and systematic reviews of primary ACLR. The Cincinnati Knee Rating Scale (CKRS), a frequently used measure of functional impairment and activity limitations produced a pooled mean of 81 in the review of revision ACLR. This is lower than reported means of CKRS scores of 86 to 94 following primary ACLR (Spindler et al., 2004). Mean Lysholm scores were also lower following ACLR revision (82.1) than in the meta-analysis by Spindler et al. (2004) following primary ACLR which ranged from 85 to >90. The mean International Knee Documentation Committee (IKDC) score of 74.8 in the meta-analysis of revision ACLR approached a minimal clinically significant difference compared with a mean of 84 in a previously reported study of primary ACLR outcomes (Wright et al., 2012). Lower scores for all three tests are indicative of a poorer functional outcome. Significantly, Wright et al. reported objective graft failure following revision ACLR as 13.7%, nearly four times the 3.67% rate of graft failure reported in the meta-analysis of prospective studies by Spindler et al. (2004).

The results of the systematic review support a previous prospective, longitudinal cohort study as part of the Multicentre Orthopaedic Outcomes Network (MOON), in which Wright et al. (2011) investigated the results of 2 year follow-up of revision ACLR. Patient-based outcome measures included the Marx Activity Scale, IKDC Subjective form, and the Knee Injury and Osteoarthritis Scale (KOOS). At 2 year follow-up, Marx scores favoured the primary ACLR group compared with the revision ACLR group (p=0.03). Similarly, IKDC scores for the primary ACLR group were higher than for the revision cohort, at 83.9 and 75.9 respectively. All subscales of the KOOS demonstrated significantly better outcomes following primary ACLR compared with revision ACLR (p≤0.005). At 2 years, median KOOS subscale Knee Related Quality of Life (KRQoL) were higher after primary (75) versus revision (62.5) ACLR, subscale Sports and Recreation were higher in the primary group (85) than the revision group (75), and Pain subscale scores were higher after primary compared with revision ACLR, at 91.7 and 83.3 respectively. These results indicate a significantly worse outcome in patient based metrics following revision ACLR. Current practice trends in evaluating an athlete's readiness to resume sporting activities following primary ACLR are inadequate at identifying those athletes at increased risk of re-injury. Evidence based knowledge of outcomes following primary and revision ACLR is necessary to drive research into improved methods of evaluating RTS readiness, allowing comparison across studies, and to provide patients with the relevant knowledge to make informed choices in their management following an ACL injury.

1.2 Thesis Objectives

Currently, no clinical practice guidelines exist to support the decision making process of orthopaedic surgeons wishing to safely return a patient to athletic participation following ACLR. The lack of consensus on the most appropriate outcome measures to use may result in patients being returned to activity prematurely, putting them at risk for subsequent re-injury. Furthermore, the lack of standardized criteria upon which successful RTS is defined has resulted in inconsistent terminology in reporting RTS rates within the literature. Little evidence exists to support the inclusion of patients' perspectives within the framework of defining successful RTS.

The overall objective of this thesis was to examine clinician based decision making processes surrounding RTS following ACLR to identify any gaps in knowledge which need to be addressed prior to any future development of clinical practice guidelines for returning an athlete to athletic participation. This was accomplished by conducting two research studies. The first research study explored patients' perspectives on self perceived RTS readiness following ACLR, and their level of satisfaction with their current level of activity following ACLR; and examined their definition of successful RTS. The second study involved an environmental survey of current clinical practice patterns of Canadian orthopaedic surgeons and registered physiotherapists.

The specific objectives of the second study were:

i. to establish the use of clinical outcome measures which contribute to RTS decisions,
ii. to establish clinicians' perspectives on the definition of successful RTS following ACLR,
iii. to gain initial insight into clinicians' support for the potential role of physiotherapists in making primary RTS decisions following ACLR.

1.3 Organization of Thesis

The relevant background information regarding epidemiology of ACL injury, knee joint anatomy, etiology of injury, non-contact ACL injury risk factors, criteria for defining successful outcome, and return to sport prognosis after ACLR are presented in Chapter 2. The first of two surveys, which comprise the research presented in this thesis, is outlined in Chapter 3, and describes patient defined measures of success following ACLR, and is formatted for submission to Physical Therapy Theory and Practice. Chapter 4 describes the decision making process for RTS following ACLR as measured by an environmental survey of Canadian orthopaedic surgeons and registered physiotherapists. The environmental survey is formatted for submission to Clinical Journal of Sport Medicine. Chapter 5 provides a discussion of the information presented in the thesis as a whole, and presents recommendation for the future directions.

REFERENCES

1. Spindler, K. P., Kuhn, J. E., Freedman, K. B., Matthews, C. E., Dittus, R. S., & Harrell, F. E. (2004). Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring does it really matter? A systematic review. *The American journal of sports medicine*, *32*(8), 1986-1995.
2. Wright, R., Spindler, K., Huston, L., Amendola, A., Andrish, J., Brophy, R., ... & Dunn, W. (2011). Revision ACL reconstruction outcomes: MOON cohort. *Journal of Knee Surgery*, *24*(04), 289-294.

CHAPTER 2
LITERATURE REVIEW

2.1 Epidemiology of ACL Injury

Anterior cruciate ligament (ACL) injuries are a high concern for young athletes competing in pivoting and jumping sports such as basketball, soccer, and volleyball. ACL injures among young female athletes present with the highest rate of incidence, with injuries occurring at 2 to 8 times the rate of their age and skill matched male counterparts (Hewett et al, 2006 and Renstrom, 2008). The disparity in injury rates between genders, combined with evidence suggesting biomechanical and neuromuscular differences are implicated in non-contact ACL injury risk factors, has prompted much scientific inquiry (Hewett et al., 2006). ACL ruptures account for significant short and long term costs to both the patient and society. The personal burden for an athlete sustaining an ACL injury is high, and includes substantial pain, decreased functional ability, loss of sports participation, increased risk of secondary meniscal or ligamentous injury to the knee, loss of potential athletic scholarships or income as a professional athlete, and the near certain risk of early or advanced osteoarthritis in the injured knee within 15 years. With over 200 000 ACL injuries occurring in the United States per year (Griffin et al., 2000), and at an estimated health care cost of $17 000 per injury (Hewett et al., 2005), ACL injuries also represent a substantial burden on society.

2.1.1. Primary ACL Injury

Primary ACL injuries may be defined as the initial rupture of the ACL diagnosed by clinical laxity and evidence of tear on MRI. The incidence of ACL injuries remains high in the young, active population, with female athletes between the ages of 14 and 19 years being at the highest risk of injury. Salmon et al. (2005) report ACL rupture rates in a healthy uninjured athletic population to be between 1.5% - 1.7%.

The mechanism of injury of ACL ruptures may be contact or noncontact in nature. Myklebust et al. (2004) define a noncontact ACL injury as an injury that occurs in the absence of player to player contact. These injuries typically occur in sports involving quick deceleration, jumping, pivoting and side-to-side movements. Contact ACL injuries are generally the result of a forced valgus, internal rotation, hyperextension mechanism associated with a collision mechanism. There is general consensus in the literature that noncontact ACL injuries represent 70% and contact ACL injuries 30% of all ACL ruptures (Hewett et al., 2006). Sports associated with the highest risk of ACL injury include football, skiing, basketball and soccer (Renstrom et al., 2008).

2.1.2. Repeat ACL Injury

Following ACLR, patients are often concerned about a repeat injury. The operational definition of repeat ACL injuries includes rupture of the primary graft, and/or injury to the contralateral ACL. Graft failure may occur due to either atraumatic, or traumatic mechanisms. Lind et al. (2009) define ACLR graft failure by the need for revision surgery. Overall graft rupture rates have been reported to be between 3% and 23% (Lind et al., 2008; Salmon et al., 2005). In a five year follow-up of 612 ACLR patients, Salmon et al. (2005) reported comparable ACL graft rupture rates (6%) and injury rates to the contralateral ACL (6%). This represents a significant increase compared with the incidence rate of ACL injury in a healthy uninjured athletic population. Several studies have noted the absence of a statistically significant difference in repeat injury rates between autogenous bone-patellar tendon-bone (BPTB) and hamstring tendon (HT) graft choices (Salmon et al., 2005). A prospective cohort study by Pinczewski et al. (2008) similarly reported no significant differences in graft rupture rates between BPTB and HT graft groups. However, BPTB grafts were associated with a higher rate of contralateral ACL rupture (22%) compared with HT grafts (10%) in their study ($p = 0.02$).

ACL graft rupture rates have been demonstrated to be the highest within the first 12 months following ACLR, with the median time from ACLR to graft rupture being 20 months (Salmon et al., 2005). In their 5 year follow-up, Salmon et al. (2005) noted that the timing of ACL graft rupture was not significantly different between BPTB and HT grafts. Contralateral ACL ruptures however, occurred significantly later, at a median of 28 months. The first 12 months after surgery appear to be a critical period for graft healing, with reported graft rupture of 18%; significantly higher when compared with contralateral ACL injuries at 2%

(Salmon et al., 2005). Graft rupture and contralateral ACL injury rates were similar after the initial 12 month period. Although overall injury rates between ACL graft ruptures and contralateral ACL injuries are comparable, the timing of repeat ACL injuries is suggestive of inadequate graft healing within the first 12 months. This has implications for the timing of medical release for resuming athletic participation following ACLR, as the first year post ACLR appears to carry the greatest risk of graft rupture.

Sporting activity which involves cutting, pivoting and side-stepping places an increased strain on the ACL and presents a risk for repeat ACL injury. With respect to mechanism of injury for repeat ACL injuries, differences have been demonstrated between graft ruptures and contralateral ACL injuries. Salmon et al. (2005) reported a 3-fold increase in incidence rate for ACL graft ruptures in those knees initially injured by a contact mechanism. Initial contact injury was not predictive of rates of contralateral ACL injuries in the same study. Risk of contralateral ACL injury was most strongly associated with a return to moderate to strenuous levels of sporting activity. The 10-fold increase in incidence rate in contralateral ACL injury may represent altered biomechanical movement patterns and incomplete rehabilitation of lower extremity function. Patient reported subjective outcomes are lower following revision ACL than after primary ACLR. Using the Knee Outcome and Arthritis Score (KOOS) and Tegner Activity Scale, Lind et al. (2008) demonstrated a significant improvement over presurgical scores in sports/recreation and quality of life KOOS subscores following primary

ACLR. Likewise, ACLR resulted in significantly increased levels of activity. The impact of revision ACLR on KOOS subscores was less, with a smaller increase in sports/recreation, quality of life, and level of activity seen. Evidence of the limited ability for revision ACLR to improve patient reported outcomes to comparable levels seen after primary ACLR supports the need for clinical practice guidelines to minimize the risk of repeat ACL injury.

2.2 Knee Joint Anatomy

A basic review of the anatomy and biomechanical function of the knee is necessary for a better understanding and interpretation of ACL injuries and surgical reconstruction.

The knee joint is essentially a hinge joint between the femoral condyles and the medial and lateral compartments of the tibial plateaus. The meniscii deepen the articular surfaces of the tibial plateaus to improve the congruency of the joint and provide increased shock absorption (Dugan, 2005). Notably, the ACL and posterior cruciate ligament (PCL) provide primary stability of the knee by preventing anterior and posterior translation of the tibia on femur, respectively. The medial collateral ligament (MCL) and lateral collateral ligament (LCL) provide secondary support, and may accompany an ACL or PCL tear with an associated valgus or varus load.

The ACL arises from the anterior intercondylar region of the tibia, and extends superiorly, posteriorly, and laterally to attach to the medial aspect of the lateral femoral condyle (Dugan, 2005). The ACL consists of the anteromedial bundle, which functions to limit anterior translation of the tibia on femur in flexion, and the posterolateral bundle which limits hyperextension of the knee (Dugan, 2005). Hamstring and gastrocnemius muscles act synergistically with the ACL as dynamic stabilizers to counteract this anterior translation, thereby unloading the ligament by reducing the stress imparted on the ACL (Lephart et al., 2002).

2.3 Etiology of ACL Injury

The disparity in injury rates between male and female athletes necessitates a more thorough understanding of the underlying causative factors, and their relationship to gender. Several mechanisms have been proposed to explain the differences; however, the underlying physiological reasons have yet to be fully elucidated. Theoretical mechanisms have been proposed based on research which has investigated ACL-injured subjects to infer causative factors (Dugan, 2005).

Most studies are in general agreement that the most vulnerable moment of the knee in non-contact ACL injuries is at the moment of ground contact during landing or deceleration prior to cutting (Dugan, 2005 and Lephart et al, 2002). Lower extremity musculature is responsible for generating and transferring forces across the knee and transferring ground reaction forces proximally during such maneuvers (Dugan, 2005). Lephart et al. (2002) describes an increased strain on the ACL during quadriceps contraction through the range of 0˚ to 45˚. Thus, noncontact ACL injury may preferentially occur during athletic manoeuvres involving shallow ranges of knee flexion, with insufficient hamstring activation to counteract the anterior translation of the tibia created by a dominant pattern of quadriceps contraction. Since it is theorized that the increased shear force created by an eccentric quadriceps contraction may be sufficient to exceed the tensile force of the ACL and cause ligamentous rupture, increased hip and knee flexion, and improved hamstring muscle recruitment timing and strength in the early ranges of flexion have been promoted as a protective mechanism in recent ACL injury prevention programs (Lephart et al., 2002). Visual analyses of these moments have interpreted the mechanism of injury to stem from increased hyperextension and valgus rotational moments at the knee, creating an increased strain in the ACL (Dugan, 2005 and Lephart et al., 2002).

2.3.1 Non-contact ACL Injury Risk Factors

Causative mechanisms of ACL injury have been theoretically divided into non-modifiable and modifiable risk factors. Within each of these two overarching themes, risk factors may be considered with as intrinsic or extrinsic to an individual. Although many risk factors are non-modifiable, and thus not amenable to injury prevention strategies, for the sake of completeness of understanding and identification of individuals at risk, they will also be briefly outlined in this paper.

2.3.1.1 Non-Modifiable Risk Factors

Non-modifiable contributory mechanisms intrinsic to the individual have been suggested to include age, gender, phase of menstrual cycle, ligament laxity, previous injury, intercondylar notch width, and anatomical alignment (Dugan, 2005). Several studies have described gender based anatomical risk factors such as a decreased intercondylar notch width and smaller size of ACL in females as being contributory risk factors due to the lower levels of linear stiffness and load to failure compared with men (Hewett et al., 2005 & Renstrom et al., 2005). Hormonal changes throughout the monthly cycle have also been implicated in an elevated risk of ACL injury among females, with the pre-ovulatory phase posing the greatest risk (Dugan, 2005, Hewett et al., 2005 & Renstrom et al., 2005). Dugan (2005) cautions that differences in anatomical parameters alone are likely not sufficient to account for injury rate disparities between male and female athletes. A complete understanding of extrinsic risk factors is limited by the multivariate nature of athletics and human movement. Non-modifiable extrinsic risk factors have been hypothesized to include the level of competition, the interaction between footwear and playing surface, weather, and sport-specific factors (Alentorn-Geli et al., 2009; Dugan, 2005; and Renstrom et al, 2008). Renstrom et al. (2008) introduced the hypothesis that a higher level of competition may be associated with an increased risk of ACL injury. Likewise, support has been voiced for the hypothesis that increased foot-floor surface traction may potentiate an increased risk of ACL injury due to the increased torsional resistance between footwear and playing surface (Renstrom et al., 2008). This relationship suggests athletes may have some ability to moderate these risk factors through the careful selection of cleats and playing surface. While these theories appear to have reasonable face validity, their contribution to risk of injury has yet to be fully elucidated, and no definitive statement regarding the nature of their relationship can be made at this time. Less amenable to intervention at the level of the individual, extrinsic risk factors are more likely to be impacted at the level of long term athlete development models and the application of rules by coaches, referees, and sport governing bodies. Further study is warranted to elucidate pertinent causative mechanisms.

2.3.1.2 Modifiable Risk Factors

In support of their proposition that injuries are not merely random events, but rather reflect underlying causes, the International Olympic Committee (IOC) Medical Commission invited multidisciplinary experts to review ACL injury risk factors as a fundamental basis for ongoing prevention research (Renstrom et al, 2008). Understanding these risk factors, and their relationship to gender-based disparities in injury rates, is paramount in identifying those athletes at risk of both primary and repeat ACL injuries, and developing theoretically sound injury prevention and rehabilitation programs (Renstrom et al, 2008).

Modifiable intrinsic risk factors have garnered the most interest in ACL injury prevention programs. Landing biomechanics, flexibility, altered neuromuscular imbalances in muscle strength and recruitment patterns have all demonstrated a correlation with increased risk of non-contact ACL injuries (Paterno et al., 2010). Research has focused on biomechanical and neuromuscular factors as the most likely risk factors associated with injury, as these salient risk factors differ between men and women (Dugan, 2005).

Understanding these underlying physiological mechanisms is critical to both the prevention and rehabilitation of ACL injuries. Lephart et al. (2002) described significant differences in proprioceptive characteristics, muscle firing patterns and landing strategies between male and female athletes. Specifically, female athletes cut and land from a jump with the hip and knee in more extended positions and with the knee at an increased valgus angle compared to male athletes (Lephart et al., 2002). The associated increased strain on the ACL brought about by high valgus rotation moments is thought to be associated with an elevated risk of injury. Inherent in this assumption is the biomechanical principle of impulse (Lephart et al., 2002). A ground reaction force distributed over a long period of time will decrease the risk of injury. Functionally, this translates into the need for increased hip and knee flexion angles to allow for maximum force dispersion and absorption in the lower extremity, and greater hamstring and gastrocnemius muscle co-activation to limit anterior translation of the tibia on femur. Drawing on this research, post surgical rehabilitation programs could benefit by advocating improved neuromuscular control during landing and pivoting moments, and increased activation of hamstring and gastrocnemius muscles throughout greater ranges of knee flexion as the basis for decreasing risk of re-injury. Similar primary ACL injury prevention programs already target athletes in high risk sport as part of their athletic warm-up.

2.4 Commonly used Outcome Measures

Commonly used measures to assess the outcome following ACLR may be classified according the World Health Organization's framework of International Classification of Functioning, Disability, and Health (ICF).

2.4.1 Measures of Body Structure and Function

2.4.1.1 KT-1000

The KT-1000 in a non-invasive knee arthrometer which measures the anterior-posterior (A-P) laxity of the tibio-femoral joint for ACL insufficiency (Isberg et al., 2006). The tibia is translated anteriorly manually, or under load, until the end point. The difference in anterior displacement between injured and uninjured sides is recorded in millimeters. Pathological laxity is defined as greater than 3 mm of side-to-side difference in anterior displacement (Brosky, Jr, et al., 1999). Good validity and reliability (ICC = 0.91-0.93) of the KT-1000 have been reported (Brosky, Jr., et al., 1999).

2.4.1.2 ACL-Return to Sport Index (ACL-RSI)

The ACL-RSI is a condition-specific scale which measures the psychological impact of returning to sport after ACLR (Webster et al., 2009). The 12-item scale measures three specific psychological constructs – emotions, confidence in performance, and risk appraisal – on a scale of a minimum of 0 to a maximum of 100 (Webster et al., 2009). A higher score reflects a more positive attitude towards returning to sport. Preliminary research demonstrated acceptable reliability (α=0.92) (Webster et al., 2009)

2.4.1.3 Single Assessment Numeric Evaluation (SANE)

The SANE was developed to assess knee function in college-aged patients after ACLR (Williams et al., 2000). The scale is consistent with the Global Knee Rating Scale (GKRS). The SANE asks patients to rate their knee on a scale of 0 to 100, with 100 being normal. The numeric rating provides the clinician with a subjective measure of the patient's perception of their functional outcome (Williams et al., 2000). The scale has been demonstrated to correlate very well with the Lysholm Activity Scale, especially at the 6 month mark post ACLR (r=0.87), when many patients are given clearance to resume athletic activity (Williams et al., 2000).

2.4.1.4 Lower Extremity Functional Scale (LEFS)

The LEFS is a self-report condition specific measure of lower extremity problems based on the concept of disability and handicap (Binkley et al., 1999). The scale consists of 20 functional items which are rated on a 5 point scale, from 0 (extreme difficulty) to 4 (no difficulty) (Binkley et al., 1999; Yeung et al., 2009). Scores for each item are summed for a maximum total of 80 points. A higher score is consistent with a higher level of function. The minimal detectable change (MDC) is 9 points (90% confidence interval [CI]). Test-retest reliability has been shown to be excellent (R=0.94). The LEFS has demonstrated good construct validity with the physical function subscale (r=0.8) and physical component score (r=0.64) of a general measure of health status, the Short Form (SF)-36.

2.4.2 Measures of Activity and Participation

2.4.2.1 Tegner Activity Level Scale

The Tegner Activity Level Scale is a self-administered subjective instrument used to measure work and activity level. It employs an 11 point Likert scale, which ranges from 0 (sick leave) to 10 (competitive athlete), with a score of 5 indicating a minimum level of physical activity consistent with a recreational athlete (Lentz et al., 2012). Patients are asked to rate their current activity level as well as their level of activity before injury. .

The scale has been validated on an ACLR patient population, and demonstrates acceptable reliability (intraclass correlation coefficient [ICC] 0.82), with a standard error of measurement (SEM) of 0.64, minimal detectable change (MDC) of 1, and acceptable floor and ceiling effects (Briggs et al., 2009).

2.4.2.2 Marx Activity Scale

The Marx Activity Scale is a self administered rating scale designed to measure a patient's level of physical activity. Developed to be completed in less than 1 minute, its simplicity of use, ease of understanding and lack of sports specificity, allows for better comparison of patient outcomes across different sports (Marx et al., 2001). It was designed to be used in conjunction with joint specific and general health outcome measures. Patients are asked to identify their activity level in their healthiest and most active state within the past year on a 5 point scale, from 0 to 4, based on the frequency of physical activity (Marx et al., 2001). A higher score denotes a higher level of physical activity. A minimal clinically important difference (MCID) has not yet been determined, although Wright et al. (2011) speculate that a difference of 2 points likely represents a clinically significant difference.

The scale demonstrated good concurrent construct validity with the CKRS (r=0.67), Tegner Activity Scale (r=0.66), and Daniel Scale (0.52) (Marx et al., 2001).

2.4.2.3 Tampa Scale for Kinesiophobia-11(TSK-11)

The TSK-11, a shortened version of the TSK, is a subjective PRO which evaluates kinesiophobia, or the fear of movement/re-injury. Eleven response items are related to somatic sensations and activity avoidance (Lentz et al., 2012). Scores on the TSK-11 range from 11 to 44 points, with higher scores representing higher levels of pain related fear of movement/re-injury (Lentz et al., 2009). The scale demonstrates good test-retest reliability (ICC = 0.81, SEM 2.54). The TSK-11 has been validated on an ACLR population (Lentz et al., 2012).

2.4.2.4 Lysholm Score

Initially designed as a physician administered measure function after knee ligament surgery, the Lysholm Score has since been validated as a patient administered standardized questionnaire of function for patients with a variety of knee injuries, including ACLR. The questionnaire asks patients to rate their level of impairment and function across 8 domains: pain, swelling, limp, squatting, instability, support, stair climbing, and locking. Total scores are ranked on a point scale of 0 to 100, with a higher score representing a higher level of function. The instrument has demonstrated acceptable test-retest reliability (ICC > 0.70, SEM 3.2) across all domains, acceptable internal consistency (α = 0.72), and floor and ceiling effects (Briggs, et al., 2009). The Lysholm Score correlates well with the IKDC (r = 0.8) and the SF-12 (0.4) with an MDC of 8.9 (Briggs, et al., 2009).

2.4.2.5 Cincinnati Knee Rating System (CKRS)

The CKRS is a self-reported measure of functional impairment and disability of the knee, which has been validated in an ACLR population. The 13 item questionnaire assesses response to patient reported symptoms, functional limitations with sports and daily activities, patient perception of the knee condition, and sports- and occupational-activity levels (Barber-Westin et al., 1999). Each item is scored on a scale from 0 to 10, with a higher score representing a higher level of function and lower symptoms. All items on the scale have demonstrated high test-retest reliability (ICC > 0.70) (Barber-Westin et al., 1999). The CKRS has been shown to demonstrate good content validity, construct validity, and item-discriminant validity (Barber-Westin et al., 1999). Responsiveness to change has shown large effect size for 7 of 8 categories (1.07 to 2.48) and a moderate effect size for the activities of daily living subscore (0.72) (Barber-Westin et al., 1999).

2.4.2.6 International Knee Documentation Committee (IKDC) Subjective Knee Form

The IKDC subjective knee form is a standardized knee specific measure of symptoms, function, and sports activity across a variety of knee disorders, including ACLR (Anderson et al., 2006; Irrgang et al., 2001). It consists of 18 questions in the domains of symptoms, functioning during activities of daily living (ADL) and sports, current function of the knee, and participation in work or sports

(Anderson et al., 2006). Scores range from 0 to 100, with higher scores indicating less disability (Lentz et al., 2012). The MDC has been reported to be 11 points (Spindler et al., 2011). The evaluation form has been found demonstrate good validity, reliability (ICC = 0.94), and responsiveness (Anderson et al., 2006; Irrgang et al., 2001). Normative data for gender and age have been described for a population cohort greater than 18 years of age (Anderson et al., 2006).

2.4.2.6 Knee Injury and Osteoarthritis Outcome Score (KOOS)

The KOOS is a sport-specific self-administered questionnaire which measures separately 5 dimensions of patient outcome: pain (9 items), symptoms (7 items), activities of daily living (ADLs) (17 items), sport and recreation function (5 items), and knee related quality of life (4 items) (Roos et al., 1998; Wright et al., 2011). Each subscale is measured on a scale of 0 to 4, then summed and transformed onto a 0-100 point scale, with 0 representing extreme knee problems, and 100 no knee problems (Roos et al., 1998; Wright et al., 2011). The MCD has been reported to be 8 points (Spindler et al., 2011). The most sensitive subscales have been demonstrated to be sport and recreation function (effect size = 1.16), and knee related quality of life (effect size = 1.65) (Roos et al., 1998). The scale has been validated for an ACLR population.

2.5 Criteria for Defining Successful Outcome

Despite advances in ACLR surgical techniques and criterion based rehabilitation, a lack of a gold standard persists in defining a successful outcome following ACLR (Lynch et al., 2013). The surgical goal of ACLR is the restoration of mechanical stability and functional capacity of the knee (Ardern et al., 2011). Implicit in this expectation is the ability of the patient to resume their desired level of sports participation once the normal biomechanics of the knee have been restored.

The definition of successful outcome is likely multifold. For an elite athlete whose primary aim is to RTS quickly, the temporal nature of medical clearance may be paramount, whereas researchers and clinicians may turn to RTS rates to define clinical success. Recently, Lynch et al. (2013) established professional consensus on preliminary criteria for defining successful outcome following ACLR at 12 and 24 months. Based on expert consensus from a broad range of sport medicine organizations, the researchers were able to identify six measures which consensus experts considered important for successful outcome following ACLR. Consensus was achieved on six measures: the absence of giving way, quadriceps and hamstrings' strength greater than 90% of the uninvolved limb, the patient having no more than a mild-knee joint effusion, patient RTS, and using patient reported outcome measures (PROs). No consensus was achieved on laxity testing as measured with instrumented testing, achieving symmetrical performance on a functional test, and measures of radiographic progression of osteoarthritis. Although PROs were identified as important measures of successful outcome, no single PRO met their operational threshold of 80% to identify consensus. The proposed individual PROs were all measures of either activity or performance. The use of patient self-report measures of satisfaction was not evaluated. The criteria upon which consensus was reached were primarily measures of impairment, despite evidence suggesting that measures of strength are unable to discriminate between individuals able to RTS and those who are not (Lentz et al., 2012). Furthermore, functional testing, which has been well shown to correlate with RTS status, was not identified as important in defining a successful outcome (Lentz et al., 2012).

On a broader level, lack of standardized criteria upon which success is defined has resulted in variations in the definition of RTS within the literature. Precise terminology is critical in identifying whether an athlete has returned to training, a lower level of pre-injury athletic activity, sports participation with functional limitations, or full competition. In a recent systematic review of 48 studies, Ardern et al (2011) identified inconsistent definitions of RTS. Stratification of studies by RTS definition resulted in varying rates of successful sports participation. Those studies which operated under the definition of return to some degree of sports participation cited a success rate of 82%. Success, as defined by studies as a return to pre-injury level of sport, was cited as 63%. This was in sharp contrast with those studies which used the more restrictive definition of return to competitive sport. Those studies reported a success rate of only

44%. If return to competitive sports participation is considered a more robust measure of postsurgical success, some previously reported rates of return may be overestimated. Standardized terminology regarding the definition of successful RTS would reduce ambiguity of results, offer more precise measures of outcome following ACLR, and facilitate cross-study comparisons.

The importance of patient satisfaction is of paramount consideration in identifying a successful outcome following ACLR. Defining postsurgical success from a patient's perspective alone, and in comparison with a clinician's perspective, however, has not been well studied. Kocher et al. (2002) prospectively studied patient satisfaction in 201 patients who had primary reconstruction of the ACL. Satisfaction with outcome was measured by the question "How satisfied are you with the outcome" on a scale of 1 to 10. The most robust associations with patient satisfaction were derived from a subjective assessment of stiffness, giving-way, swelling, and patellofemoral symptoms. Similar strong correlations were found between patient satisfaction and functional outcome, as measured by the components of the Lysholm knee score ($p < 0.001$), and performance, as measured by activity level and sports participation ($p < 0.001$). In a cohort study of patient perspectives, Roos et al. (2001) compared patients' and surgeons' remembered expectations, satisfaction, current knee function and activity level one year after ACLR. Results demonstrated that surgeons reported significantly better outcomes in current knee function, experienced instability, confidence in the knee, and activity level than patients

($p \leq 0.008$). The discrepancy in rating between groups increased as patient reported outcome became worse. No differences were seen between patient and surgeon reported outcomes of postsurgical expectations and patient satisfaction. The implication of observer bias from clinician administered measures of patient outcome may be the overestimation of successful postsurgical outcomes (Roos, 2001). The administration of validated self-administered questionnaires of symptoms and function, such as the Lysholm Knee Scale, CKRS, ACL-RSI, SANE, or IKDC subjective may reduce observer bias, and introduce a patient's perspective in the determination of success following ACLR.

An integral component of successful RTS is the ability to do so safely, with consideration for subsequent risk of re-injury and the premature development of osteoarthritis following ACLR. The abnormal neuromuscular control pattern of dynamic knee valgus, quadriceps loading, in shallow degree of hip flexion has been identified in previous studies (Hewett et al., 2005; Paterno et al., 2013) as a modifiable risk factor in predicting primary ACL injuries. These neuromuscular control patterns which have been demonstrated to be predictive of initial ACL injuries have been hypothesized to also have predictive value in identifying repeat ACL injuries. Preliminary prospective research (Paterno et al., 2010) identified altered lower extremity neuromuscular control patters during jumping and deficits in postural stability as strong predictors of a repeat ACL injury in athletes who had returned to a cutting or pivoting sport following ACLR. The subsequent patient outcomes following repeat ACL injury and revision surgery are extremely poor (Hewett et al., 2013 and Spindler et al., 2011). Confirmed identification of variables predictive of repeat ACL injuries will be instrumental in the development of rehabilitation guidelines and determining clinical outcome measures of return to sport.

2.6 Return to Sport Prognosis after ACLR

It is concerning that only between 20% and 50% of those athletes who have sustained an ACL injury return to the same sports following ACLR (Gobbi and Francisco, 2006; Kvist and Ek, 2005; Wiger et al, 1999). Moreover, of those athletes who do return to athletic activities, 10% to 70% of the athletes continue to experience significant functional limitations, and resume at a lower level of sports participation (Smith et al., 2004). Clearly, restoring the stability of the knee with reconstructive surgery does not guarantee the pre-injury status of high level sports participation. Table 2.1 presents the RTS rates of athletes based on varying definitions of successful RTS, and their relationship to clinical outcome measures of function. Although published incidence rates of ACL injury are higher among women, demographic analysis in the studies below report a higher overall percentage of male athletes. This discrepancy is the result of the population studied, with male dominant sports (Australian netball, football, professional athletes) and military recruits biasing the inclusion of male participants. Thus, the absolute number of male athletes is higher in these studies.

Table 2.1 Return to sport rates following ACLR

Study	Demographics	Clinical Outcome Measures	Results	Return to Sport Rate
Ardern et al. (2011a) Level of evidence IV	503 patients (340 men, 163 women Mean 53.4 weeks post surgery Mean age 27.2 years)	Follow up at 12 months; Subjective Evaluation; CKRS; IKDC; single leg hop test; cross over hop test	No correlation between RTS rates and IKDC; hop test LSI ≥85% significantly more likely to RTS (RR 2.5)	168 patients (33.4%) attempted full competition 169 (33.6%) attempted training and/or modified competition
Ardern et al. (2011b) Level of Evidence I	48 studies; 5770 participants (64% men, 36% women); mean age 25.1 years; mean follow-up 41.5 mo.	Meta-analysis and systematic review; pooled-return to sport rate	90% successful based on measures of impairment ; 85% successful on activity based measures	Returned to competitive sport 44%

Kvist et al. (2005)	62 patients *34 men, 28 women)	Follow up at 3-4 years; KOOS; TSK11	Negative correlation between TSK and KOOS (r=-0.50, p<0.05); 24% No-RTS reported fear of re-injury	RTS rate 53%
Langford et al. (2009)	87 athletes (55 men, 32 women); mean age 27.5 years 3,6,and 12 months post ACLR	Emotional Response of Athletes to Injury Scale; ACL-RSI; Passive knee ROM; effusion; stability tests (Lachman and Pivot shift); Knee laxity (KT1000); hop	No statistically significant differences between groups in measures of impairment and physical function; patients who had RTS demonstrated significantly	At 12 months post ACLR, all athletes had been medically cleared to RTS 51% returned to competitive sport; 49% no return to sport

		tests (single leg hop for distance, crossover hop for distance)	higher ACL-RSI scores	

Lentz et al. (2009) suggest that incomplete rehabilitation may be a factor in the failure to return athletes to pre-injury athletic participation, if athletes are allowed to RTS prior to their impairments being sufficiently resolved. The current paucity of evidence to support optimal rehab status makes it difficult to make evidence based decisions. Unfortunately, standardized clinical guidelines do not exist to assist clinicians in making RTS decisions, and little consensus exists on which outcome measures best evaluate an athlete's functional status. Furthermore, the preponderance of research in the development of postsurgical outcome measures focuses on measures of impairment and disability. Measures of impairment, such as strength, ROM, laxity, girth, and swelling, have been shown to correlate poorly to measures of activity (Lephart et al., 1992; Ross et al., 2002). It is arguable, that these static measures of impairment do not accurately represent the high dynamic load placed on the knee during strenuous sports participation. This puts into question the validity of current measures of evaluating postoperative levels of sport participation, whose constructs are based on measures of impairment, in establishing return to play readiness.

Functional performance tests are most commonly used to evaluate an athlete's functional status, with the underlying assumption that tests of physical performance simulate stresses about the knee experience during athletic activity. In the absence of strong research that validates their correlation with level of athletic participation, caution should be exercised in the interpretation of any results beyond the level of disability in patients following ACLR.

Uniquely, Ardern et al. (2011) investigated the relationship between hop tests and return to pre-injury levels of activity in patients following ACLR, and observed a high correlation between levels of performance on functional tests and return to pre-injury levels of activity. Clearly further research is warranted in further investigating the relationship between functional performance measures and participation in pre-injury levels of sport.

Lephart et al. (2002) were amongst the first to study the association between impairment based measures of physical function and functional performance. They found a poor correlation ($r = 0.01$ to $r = 0.42$) between measures of strength, laxity, ROM, thigh girth, and functional performance. In a similar study, Lentz et al. (2009) investigated the relationship between knee impairment, kinesiophobia and function. Their findings demonstrated that pain, quad strength, kinesiophobia and knee flexion restriction correlated with self reports of function only. Only knee effusion was associated with a performance based test, the single leg hop test. Barber-Westin and Noyes (2011) performed a systematic review of published studies to identify which clinical criteria had been investigated over the previous 10 years to determine RTS status following ACLR. Their study revealed serious discrepancies between objective criteria used to make return to sport decisions. Of the 716 studies they identified, only 35 (13%) presented objective criteria for their decisions (muscle strength or thigh circumference – 28; general knee exam – 15; single leg hop test – 10; Lachman – 1; validated questionnaires). Barber-Westin and Noyes (2011) subsequently published a list of proposed criteria for release to full sports participation (limb symmetry index on single leg hop test, quadriceps strength, lack of pain or effusion, full ROM, functional knee stability, surgical and psychosocial factors). The authors should be commended for their comprehensive multifaceted approach; however, the criteria are based primarily on expert opinion. Future study is warranted to validate the predictive value of the various constructs for successful RTS and reduced risk of re-injury. Given the complex nature of physical and mental demands on athletes to perform successfully in sports, it makes sense that a complex diagnostic tool be validated that correlates multidimensional deficits with measures of participation. Lentz et al. (2009) have suggested that both patient self-report and performance based measures be used to evaluate function, as they can come to different conclusions.

Given the extensive personal burden of pain and disability following an ACL injury, it is conceivable that fear of re-injury is a psychological variable with the potential to impede RTS after ACLR (Kvist et al., 2005). Indeed, a high fear of re-injury has been correlated with a poor self report of function (Kvist, 2005).

Exploring the relationship between kinesiophobia and sports with the Tampa Scale of Kinesiophobia (TSK), Kvist et al. (2005) demonstrated high TSK scores to be correlated in ACLR patients with decreased activity levels compared with those who had resumed pre-injury levels of sports participation. Recently, the ACL-RSI has been introduced as a further measure to evaluate the psychological impact of returning to sport after ACLR surgery (Webster et al., 2008). Thus the potential role of kinesiophobia as a determinant in the return to play readiness of athletes following ACLR warrants further investigation.

Controversy still exists in the clinical practice of prescribing a functional brace for rehabilitation and return to athletic activities. Proponents of functional bracing following ACLR cite their belief that post surgical outcomes may be improved by increasing passive knee extension, decreasing pain and graft strain (Möller et al., 2001; Wright and Fetzer, 2007). Although the use of bracing is widely used, a recent systematic review of Level-I and II studies does not support its efficacy in improving functional outcomes (Kruse et al., 2012). Regardless of type of brace (immobilization, functional or rehabilitation) bracing was not found to protect against post-operative injury, decrease pain, alter range of knee motion, or improve stability following ACLR (Kruse et al., 2012). The authors concluded that post-operative bracing provided no benefit, and added an unnecessary expense to rehabilitation. This systematic review supports several previous prospective randomized controlled studies which showed no statistically significant correlation between bracing and measures of strength, functional hop tests, ROM, knee circumference, Lysholm scale, IKDC, and the Tegner activity level scale (Kartus et al., 1997; McDevitt et al., 2004; & Möller et al., 2001). In a systematic review of Level I evidence to determine if sufficient evidence exists to support the use of post ACLR functional bracing, Wright and Fetzer (2007) reported that brace use provided no improvements in ROM, graft stability or protection from subsequent injury. Although small but significant improvements in static proprioception have been demonstrated with functional bracing, this does not appear to translate into improvements in functional hop tests (Birmingham et al., 2001; Risberg et al., 1999; & Wu et al., 2001). Current evidence refutes the use of bracing following ACLR, and should be reflected in clinical practice standards.

Currently, there is no consensus as to when an athlete can or should RTS. Discrepancies between RTS protocols vary between 4 months and 12 months postoperatively (Cascio et al., 2004, Kvist et al., 2004). These decisions seem increasingly based on the desire to resume athletic activity, and not a strong evidence-based practice. With surgeons pushing the boundaries of accelerated RTS following ACLR, the measure of successful rehabilitation is increasingly how fast the athlete resumes their athletic career. Given the high ACLR re-injury rates, this begs the question: Are we returning our athletes to sport before they are safely ready to resume athletic activity, and with insufficient evidence to support our decisions? Fundamental to this question is an understanding of current clinical practice patterns compared with evidence based measures.

Prospectively identifying which of these measures are associated with successful participation in pre-injury levels of sporting activities will be crucial to the development of clinical decision rules in returning athletes to sport.

REFERENCES

1. Alentorn-Geli, E., Myer, G., Silvers, H., Samitier, G., Romero, D., Lázaro-Haro, C., and Cugat, R. (2009). Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. *Knee Surgery, Sports Traumatology, Arthroscopy,* 17(7),705-729
2. Ardern, C. L., Taylor, N. F., Feller, J. A., & Webster, K. E. (2012). Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *The American Journal of Sports Medicine, 40*(1), 41-48.
3. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to sport following anterior cruciate ligament reconstruction surgery: A systematic review and meta-analysis of the state of play. *British Journal of Sports Medicine, 45*(7), 596-606.
4. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery two-thirds of patients have not returned by 12 months after surgery. *The American Journal of Sports Medicine, 39*(3), 538-543.
5. Barber-Westin, S. D., & Noyes, F. R. (2011). Factors used to determine return to unrestricted sports activities after anterior cruciate ligament

reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 27*(12), 1697-1705.

6. Barber-Westin, S. D., & Noyes, F. R. (2011). Objective criteria for return to athletics after anterior cruciate ligament reconstruction and subsequent reinjury rates: A systematic review. *The Physician and Sportsmedicine, 39*(3), 100-110. doi: 10.3810/psm.2011.09.1926; 10.3810/psm.2011.09.1926
7. Birmingham, T.B., Kramer, J.F., Kirkley, A., Inglis, J.T., Spaulding, S.J., & Vandervoort, A.A. (2001). Knee bracing after ACL reconstruction: effects on postural control and proprioception. *Medicine and Science in Sports and Exercise*, 33(8), 1253-1258.
8. Cascio, B.M., Culp, L., & Cosgarea, A.J. (2004). Return to play after anterior cruciate ligament reconstruction. *Clinical Sports Medicine,* 23, 395-408, ix.
9. Dugan, S. A. (2005). Sports-related knee injuries in female athletes: What gives? *American Journal of Physical Medicine & Rehabilitation, 84*(2), 122-130.
10. Gobbi, A., & Francisco, R. (2006). Factors affecting return to sports after anterior cruciate ligament reconstruction with patellar tendon and hamstring graft: A prospective clinical investigation. *Knee Surgery, Sports Traumatology, Arthroscopy, 14*(10), 1021-1028.

11. Hewett, T. E., Di Stasi, S. L., & Myer, G. D. (2013). Current concepts for injury prevention in athletes after anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine, 41*(1), 216-224.
12. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.
13. Hewett, T. E., Myer, G. D., & Ford, K. R. (2006). Anterior cruciate ligament injuries in female athletes part 1, mechanisms and risk factors. *The American Journal of Sports Medicine, 34*(2), 299-311.
14. Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Colosimo, A. J., McLean, S. G., . . . Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes A prospective study. *The American Journal of Sports Medicine, 33*(4), 492-501.
15. Kartus, J., Stener, S., Köhler, K., Sernert, N., Eriksson, B. I., & Karlsson, J. (1997). Is bracing after anterior cruciate ligament reconstruction necessary? A 2-year follow-up of 78 consecutive patients rehabilitated with or without a brace. *Knee Surgery, Sports Traumatology, Arthroscopy*, *5*(3), 157-161.
16. Kocher, M. S., Steadman, J. R., Briggs, K., Zurakowski, D., Sterett, W. I., & Hawkins, R. J. (2002). Determinants of patient satisfaction with outcome

after anterior cruciate ligament reconstruction. *The Journal of Bone & Joint Surgery*, *84*(9), 1560-1572.

17. Kvist, J., Ek, A., Sporrstedt, K., & Good, L. (2005). Fear of re-injury: A hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 13*(5), 393-397.
18. Langford, J. L., Webster, K. E., & Feller, J. A. (2009). A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine, 43*(5), 377-378.
19. Lentz, T. A., Tillman, S. M., Indelicato, P. A., Moser, M. W., George, S. Z., & Chmielewski, T. L. (2009). Factors associated with function after anterior cruciate ligament reconstruction. *Sports Health: A Multidisciplinary Approach, 1*(1), 47-53.
20. Lephart, S. M., Abt, J. P., & Ferris, C. M. (2002). Neuromuscular contributions to anterior cruciate ligament injuries in females. *Current Opinion in Rheumatology, 14*(2), 168-173.
21. Lephart, S. M., Perrin, D., Fu, F., Gieck, J., McCue, F., & Irrgang, J. (1992). Relationship between Selected Physical Characteristics and Functional Capacity in the Anterior Cruciate Ligament Insufficient Individual, *Journal of Orthopaedic and Sports Physical Therapy, 16(4), 174-181.*

22. Lind, M., Menhert, F., & Pedersen, A. B. (2009). The first results from the Danish ACL reconstruction registry: epidemiologic and 2 year follow-up results from 5,818 knee ligament reconstructions. *Knee Surgery, Sports Traumatology, Arthroscopy*, *17*(2), 117-124.
23. Lynch, A. D., Logerstedt, D. S., Grindem, H., Eitzen, I., Hicks, G. E., Axe, M. J., ... & Snyder-Mackler, L. (2013). Consensus criteria for defining 'successful outcome'after ACL injury and reconstruction: a Delaware-Oslo ACL cohort investigation. *British journal of sports medicine*.
24. McDevitt, E.R., Taylor, D.C., Miller, M.D., Gerber, J.P., Ziemke, G., Hinkin, D., …& Pierre, P.S. (2004). Functional bracing after anterior cruciate ligament reconstruction: A prospective, randomized, multicentre study. *The American journal of sports medicine*, 32(8), 1887-1892.
25. Möller, E., Forssblad, M., Hansson, L., Wange, P., & Weidenhielm, L. (2001). Bracing versus nonbracing in rehabilitation after anterior cruciate ligament reconstruction: a randomized prospective study with 2-year follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *9*(2), 102-108.
26. Myklebust, G., Engebretsen, L., Brækken, I. H., Skjølberg, A., Olsen, O. E., & Bahr, R. (2003). Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. *Clinical Journal of Sport Medicine*, *13*(2), 71-78.

27. Paterno, M. V., Rauh, M., Schmitt, L. C., Ford, K. R., & Hewett, T. E. (2013). Incidence of Second Anterior Cruciate Ligament (ACL) Injury 2 Years after Primary ACL Reconstruction and Return to Sport. *Orthopaedic Journal of Sports Medicine*, *1*(4 suppl), 2325967113S00002.
28. Paterno, M. V., Schmitt, L. C., Ford, K. R., Rauh, M. J., Myer, G. D., Huang, B., & Hewett, T. E. (2010). Biomechanical measures during landing and postural stability predict second anterior cruciate ligament injury after anterior cruciate ligament reconstruction and return to sport. *The American Journal of Sports Medicine*, *38*(10), 1968-1978.
29. Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., . . . Krosshaug, T. (2008). Non-contact ACL injuries in female athletes: An international olympic committee current concepts statement. *British Journal of Sports Medicine, 42*(6), 394-412.
30. Risberg, M. A., Beynnon, B. D., Peura, G. D., & Uh, B. S. (1999). Proprioception after anterior cruciate ligament reconstruction with and without bracing. *Knee Surgery, Sports Traumatology, Arthroscopy*, *7*(5), 303-309.
31. Ross, M. D., Irrgang, J. J., Denegar, C. R., McCloy, C. M., & Unangst, E. T. (2002). The relationship between participation restrictions and selected clinical measures following anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 10*(1), 10-19.

32. Salmon, L., Russell, V., Musgrove, T., Pinczewski, L., & Refshauge, K. (2005). Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, 21(8), 948-957.
33. Smith, F., Rosenlund, E., Aune, A., MacLean, J., & Hillis, S. (2004). Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine, 38*(3), 279-284.
34. Snyder-Mackler, L., Fitzgerald, G.K., Bartolozzi, A.R., and Ciccotti, M.G. (1997). The relationship between passive joint laxity and functional outcome after anterior cruciate ligament injury. *American Journal of Sports Medicine*, 25(2), 191-195.
35. Spindler, K. P., Huston, L. J., Wright, R. W., Kaeding, C. C., Marx, R. G., Amendola, A., . . . Harrell, F. E. (2011). The prognosis and predictors of sports function and activity at minim*um 6 years after anterior cruciate liga*ment reconstruction A population cohort study. *The American Journal of Sports Medicine, 39*(2), 348-359.
36. Webster, K. E., Feller, J. A., & Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Physical Therapy in Sport, 9*(1), 9-15.

37. Wiger, P., Brandsson, S., Kartus, J., Eriksson, B. I., & Karlsson, J. (1999). A comparison of results after arthroscopic anterior cruciate ligament reconstruction in female and male competitive athletes A two-to five-year follow-up of 429 patients. *Scandinavian journal of medicine & science in sports*, *9*(5), 290-295.

38. Wright, R.W., & Fetzer, G.B. (2007). Bracing after ACL reconstruction: a systematic review. *Clinical orthopaedics and related research*, 455, 162-168.

39. Wu, G. K., Ng, G. Y., & Mak, A. F. (2001). Effects of knee bracing on the sensorimotor function of subjects with anterior cruciate ligament reconstruction. *The American journal of sports medicine*, *29*(5), 641-645.

CHAPTER 3

PATIENT DEFINED MEASURES OF SUCCESS FOLLOWING ACLR

ABSTRACT

Purpose: The purpose of this study was to explore patients' perspectives on self perceived RTS readiness following ACLR; to compare patients' level of satisfaction with their current level of activity following ACLR; and examine their definition of successful RTS.

Design: Cross sectional study.

Setting: Online

Participants: Athletes, competitive at a minimum recreational level pre-injury, who had undergone ACLR within the previous 6-18 months.

Interventions: Patients completed a web survey consisting of 19 questions about their activity level, their experience surrounding the process of rehabilitation after ACLR, and their decisions surrounding returning to sport.

Main Outcome Measures: Descriptive and subjective data were collected and analyzed. Frequency data was collected for the definition of successful RTS following ACLR using a self-report survey. The relationship between patient satisfaction and current level of activity following ACLR was compared using the Tegner Activity Scale and SANE.

Results: 15 patients were recruited through physician advertising; intercollegiate membership at a Canadian university; email distribution lists for several Canadian

Provincial Sporting Organization (PSOs) for Basketball, Volleyball, and Field Hockey teams; and online blog spots. All patients were unanimous in their definition of successful RTS after ACLR as the ability to fully participate in pre-injury level of sport with no limitations or deficits (100%) and restoring functional stability (100%). Mean Tegner activity level scores of respondents decreased a mean of 3.4 (SD ± 2.5) from pre-injury to current level of activity ($p < 0.011$). However, no significant decrease from pre-injury level of activity to expected level of activity post surgery was seen. A statistically significant correlation was demonstrated between patients' level of satisfaction and current level of activity ($r = 0.84$, $p = 0.02$), with higher levels of activity associated with increased levels of satisfaction. Barriers to data collection were identified as low patient participation and the lack of direct follow up with surgeons to ensure assistance with study advertising.

Conclusions: Following ACLR, medically cleared patients had not met their high expectations of functional stability and ability to pre-injury level of RTS. The discordance between unmet expectations and current level of sporting activity was reflected in lower rates of patient satisfaction. While internet mediated survey methods hold potential for increase ease and lower cost of patient recruitment, this study did not demonstrate the feasibility of this method in recruiting large numbers of patients.

Key Words: ACL reconstruction, knee injury, return to sport, outcome measure

3.1 Introduction

Clinical assessment of patient outcome may be best described using the International Classification of Functioning, Disability, and Health (ICF) model as a framework to guide clinical decision making. Using the ICF model of functioning and disability, clinicians can identify pertinent patient specific limitations across the health domains of impairments, activity, and participation (Irrgang, 2008). Evidence based interventions and clinical outcome measures need to reflect a patient's individual limitations within the framework in order to maximize patient care and recovery. Knowledge of which clinical outcome measures apply within the context of the model is fundamental in its correct application.

Applying the ICF model to ACL injuries, impairment of body structure would describe rupture of the ACL, along with any concomitant structural damage to the menisci, articular cartilage, underlying subchondral bone, or collateral ligaments of the knee (Irrgang, 2008). Measures of impairment of body function might include pathologic laxity, effusion, decreased range of motion, reduced muscle activation and strength, changes in proprioception, altered neuromuscular activity, biomechanical deficits, and subjective reports of giving way. Clinical outcome measures designed to reflect limitations in body function include mechanical (e.g. KT1000) or clinical measures of laxity (e.g. Lachman, pivot shift), swipe tests, goniometry, isometric or isokinetic strength testing, balance testing, patient movement patterns, and patient self-report measures. Activity limitations associated with ACL injuries might include difficulty with walking, running, climbing stairs, squatting, and jumping. Outcome measures frequently directed at a patient's level of activity limitation include the IKDC subjective form, the CKRS, Lysholm Knee Scale, the LEFS and a battery of hop tests. At the level of participation, patients may be restricted in their ability to participate in a defined level of sports activity. Clinical outcome measures validated at the level of participation include the Tegner Activity Scale, and the Marx Activity Scale.

Given that the ultimate goal of ACLR is not solely the restoration of mechanical stability of the injured knee, but the return of a patient to pre-injury level of sport, evaluation at the level of participation within the framework of the ICF model is critical. Assessment of clinical outcome post ACLR needs to address a patient's limitations across all health domains of impairment, activity and participation.

Kocher et al. (2002) investigated determinants of patient satisfaction with outcome after primary ACLR at all levels of the ICF. A cohort of 201 patients, ages 14 to 60 years of age, were studied prospectively over a minimum of a 2 year follow-up. 56.9% of the patients studied were male. Patient satisfaction was determined by asking patients to respond on a 10 point Likert scale to the question: "How satisfied are you with your outcome?". In a multivariate analysis of the responses, the 7 variables which accounted for 83% of the variability in scores (R^2 = 0.83) were the Lysholm Knee Score, IKDC subjective and ROM subscores, patellar tenderness, full giving way, flexion contracture, and swelling. No statistical significance was associated with age, gender, chronicity of injury, duration of follow-up, or side of involvement. Patient dissatisfaction was most highly associated with subjective measures of pain, swelling, giving way, locking, noise, stiffness and limp. The robust relationship between patient satisfaction and measures of symptoms and function led Kocher et al. (2002) to stress its importance in the assessment of ACLR outcome.

Current health care models emphasize the role of patient satisfaction in outcomes research as an essential means for assessment of quality of care, assessment of the health care delivery, patient care models, continuous quality improvements, general health status, and the economics of health care delivery (Kocher et al. 2002). Thompson and Sund (1995) postulate that patients derive their level of satisfaction by comparing their prior expectations with their perception of actual results. This implies that expectations are associated with a subjective measure of outcome, rather than the achievement of an absolute objective measure. Thompson and Sund (2002) defined 4 categories of expectations: ideal, being the preferred or wanted outcome; predicted, being the realistic, or practical outcome; normative, which is what the patient is led to believe should happen; and an unformed expectation, in which a patient is unable to articulate their understanding. Theoretically, maximum satisfaction should be derived when objective outcome measures coincide with subjective measures of ideal expectations. This is consistent with Wooley et al. (1978) who found expectation of outcome to be an important predictor of satisfaction in patients with acute illness. The study also demonstrated that patient satisfaction could be predicted based on the level of communication about the expected outcome between the patient and the physician. These findings have implications for the extent to which surgeons facilitate patients' understanding of functional outcomes and realistic RTS and re-injury rates following ACLR.

Understanding a patient's perspective on the definition of success following ACLR, and the relationship between presurgical expectations and level of satisfaction with outcomes has not been well studied. To assess whether current outcome measures address patients concerns and expectations, a patients' perspectives need to be explored to inform future research.

The purpose of this study was to explore patients' perspectives on self perceived RTS readiness following ACLR, to compare patients' level of satisfaction with their current level of activity following ACLR; and examine their definition of successful RTS.

3.2 Methods

3.2.1 Study Design

Patients were asked to answer 19 closed-ended questions regarding demographics, activity level, satisfaction, and limiting factors in RTS. Patients' activity level was measured by 4 validated self-reported outcome measures, the Marx Activity Scale, the Tegner Activity Scale, Single Assessment Numeric Evaluation (SANE) and the ACL - Return to Sport after Injury (ACL-RSI). Additionally, patients in this study were asked to rate their expected level of activity after surgery.

Demographic and subjective information requested from patients included age, gender, time from injury to surgery, time since surgery, graft type, concomitant surgical procedures, previous ACL repairs, deciding factors for choosing ACLR versus conservative management, RTS timeline, satisfaction with current activity level, level of endorsement for proposed definitions of successful RTS, and reasons for activity restrictions (See Appendix G). Patients were informed that they could withdraw from the study at any time without repercussion. Patients were required to provide inform consent prior to being able to gain access to the online survey, through a forced choice option in the program. All data was collected anonymously. Ethical approval was provided by the Hamilton Integrated Research Ethics Board, and the University of Toronto Research Ethics Board.

3.2.2 Recruitment Protocol

Patients were sought to participate in an online survey regarding their experiences following ACLR. Patient participation was advertised between April and July, 2013 via 4 main routes: Sports medicine specialists and orthopaedic surgeons were asked to display a poster in their clinic advertising enrollment in the study; a web link to the online survey was posted on various blog sites focused on knee injuries and RTS; the patient recruitment poster was distributed via email to all varsity athletes at a Canadian university; and the poster was distributed to senior athletes through email distribution lists for Basketball, Volleyball, and Field Hockey from several Canadian PSOs.

Inclusion criteria for eligible participants included adults aged 18-50 years who had had their ACL reconstructed within the past 6 to 18 months, and were able to understand English. In accordance with the scale's defined levels of activity, a score of at least 5 on the Tegner Activity Scale was accepted to ensure participants were physically active at a minimum of a recreational level. In an effort to improve generalizability of results and acquire a greater depth of understanding of limiting factors, no exclusion criteria were stipulated for prior or concomitant knee injuries, or non-physical reasons for inability to RTS following surgery.

3.3 Results

A total of 15 patients responded to the study (5 men, 7 women, and 3 unreported gender; mean age, 37.6 years; range 15-50 years). Mean time post surgery was 11.7 (range 6-18 months). Patients most frequently reported receiving a BPTB graft (33%), followed by HT (27%), and allograft (27%) in their ACLR. Three patients did not respond to the question. One patient underwent double revision-ACLR using both HT and BPTB grafts. Of the remaining 3 patients who underwent revision ACLR, HT graft was used once, and an allograft was chosen twice to perform the revision surgery. An analysis of the data revealed that response to the survey was equally distributed between respondents accessing the survey directly and those participating through a link on various blog sites. The average time of survey completion for patients was advertised at 5-10 minutes, and actual completion time was 6:09 minutes, with 55% of questions left unanswered. Demographic information for patient participants is presented in Table 3.1.

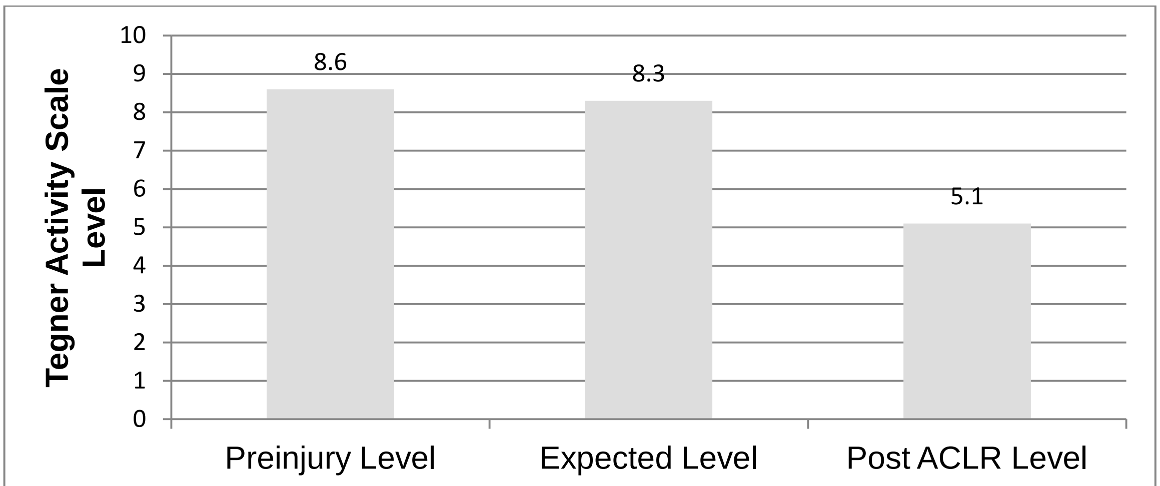
Table 3.1 Patient Demographics

Patient Demographics	**Number**	**Mean**	**Range**	**Percentage**
Male	5			33.3
Female	7			46.7
Unreported	3			20
Age (years)		X= 37.6	15-50	
Months since injury		X=15.0	7-18	
Months since surgery		X=11.7	6-18	
Graft				
Patellar tendon	5			33.3
Hamstring	4			26.7
Allograft	4			26.7
Unreported	2			13.3
Previous ACLR	4			26.7

A majority of patients (41.2%) cited instability as the reason for pursuing surgical reconstruction of their ACL, almost double those reporting desire to return to pre-injury level of sport (23.5%) as the reason for surgery. Pain and weakness each accounted for 11.8%, with problems with knee function responsible for only 5.9% of surgical management. Nonresponse rate was 5.8%. Together, the two most commonly cited reasons for choosing surgical reconstruction of an ACL deficient knee accounted for 64.7% of responses, compared with 5.9% of patients citing functional difficulty with the knee.

Mean Tegner activity level scores, as presented in Figure 3.1, decreased a mean of 3.4 (SD ± 2.5) from pre-injury to current level of activity in all respondents ($p < 0.011$). However, there was no statistically significant decrease from pre-injury level of activity to expected level of activity post surgery.

Figure 3.1 Highest level of activity of participants on the Tegner Activity Scale*



Level 10	Competitive sports- soccer, football, rugby (national elite)
Level 9	Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball
Level 8	Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing
Level 7	Competitive sports- tennis, running, motorcars speedway, handball Recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running
Level 6	Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week
Level 5	Work- heavy labor (construction, etc.) Competitive sports- cycling, cross-country skiing, Recreational sports- jogging on uneven ground at least twice weekly
Level 4	Work- moderately heavy labor (e.g. truck driving, etc.)
Level 3	Work- light labor (nursing, etc.)
Level 2	Work- light labor Walking on uneven ground possible, but impossible to back pack/hike
Level 1	Work- sedentary (secretarial, etc.)
Level 0	Sick leave or disability pension because of knee problems

All patients were unanimous in their definition of successful RTS as the ability to fully participate in pre-injury level of sport with no limitations or deficits (100%) and restoring functional stability (100%). Only 28.6% of patients had actually returned to their pre-injury level of sporting activity. A statistically significant correlation was demonstrated between patients' level of satisfaction and current level of activity and ($r = 0.84$, $p = 0.02$). Likewise, a statistically significant inverse relationship was demonstrated between the difference in Tegner scores between pre-surgical expectations, current level of activity, and level of satisfaction ($r = 0.76$, $p = 0.05$). Unfortunately, the contribution of psychosocial variables was unable to be explored since no patient respondents completed the ACL-RSI measure.

3.4 Discussion

The primary purpose of this study was to explore patients' perspectives on self perceived RTS readiness following ACLR. Patient responses demonstrated inconsistencies in perceived readiness to RTS juxtaposed against timelines for having received medical clearance to RTS. A secondary objective was to compare patients' level of satisfaction with their current level of activity following ACLR. Patient satisfaction was strongly related to both their current level of activity, and differences between their pre-surgical expectations and current level of activity. The final objective was to examine the patient-relevant definition of successful RTS. Importantly, there was unanimous agreement amongst patients with the definition of successful RTS following ACLR.

Although all patients in this study reported to have returned to sporting activities, only 28.6% had returned to their pre-injury level of sport. Given previous study findings that RTS at a pre-injury level is a major determinant in pursuing ACLR, it is concerning that only two-thirds of patients have been found to have achieved this outcome at short term follow up (Ardern et al., 2011a). Published post ACLR RTS rates can vary significantly, depending on the definition of participation level used. The discrepancy with current RTS rates and those previously reported may be explained by the high proportion of older athletes, as well as those reporting revision ACLR. Ardern et al. (2011b), in a systematic review of 48 studies, reported return to competitive sport rates of only 44% of athletes, despite 90% of participants scoring normal or near normal on measurements of impairment, and 85% scoring normal on activity based outcomes. This suggests that existing outcome measures do not adequately assess criterion factors necessary to attain this goal.

Athletes are typically permitted to resume athletic participation between 6 and 12 months post ACLR (Kvist 2005). However, all but one of the respondents in this current study didn't feel ready to resume athletic participation until several months after being medically cleared for sporting activity. A similar result was found in a previous qualitative study of patients' experiences, in which none of the respondents perceived themselves to be fully recovered at 6 months, with the majority still not ready to resume pre-injury levels of activity at 12 months post surgery (Heijne et al., 2008).

Trends in this current study suggest that patient satisfaction is strongly related to both their current level of activity, and differences between their pre-surgical expectations and current level of activity. Patients with expectations of returning to their pre-injury level of activity were unsatisfied with returning to a lower level athletic participation. The inability to resume pre-injury sporting activities often reflects a combination of several factors. Both primary and revision ACLR have inherent limitations in their ability to restore the rotary biomechanics of the knee. Together with the loss of proprioceptive input due to removal of the native ACL, these two factors impact the ability to stabilize the knee. Additionally, persistent functional limitations may persist if all impairments are not identified through the use of appropriate outcome measures. Despite being well correlated to the ability to RTS, measures of fear of re-injury are infrequently used. The contribution of psychological factors may play a key role in a patient's ability to return to a pre-injury level of sport. As well, patients may possess unrealistic expectations of outcomes following ACLR and the timely return to sporting activity. Frank discussion between the surgeon and the patient prior to ACLR about realistic functional and participatory expectations may increase patients' acceptance of post ACLR limitations, and decrease their levels of dissatisfaction. Prospective studies are needed to confirm whether differences between pre-surgical expectations and current level of activity remain predictive of patient level of satisfaction.

Framed by the ICF model, patients' definitions of successful RTS were expressed in the domains of limitations in physical functioning and participation. This is consistent with two-thirds of the patients citing instability and RTS at a pre-injury level activity as their primary reasons for pursuing surgical management of an ACL rupture. While the goal of ACLR is to restore structural stability of the knee, the subjective feeling of giving way encompasses both the ability to passively and dynamically control the knee during functional movement. It is often difficult to disentangle the contribution of impairment, function and participation to a patient's overall level of postsurgical satisfaction.

The methodology of the current study made it impossible to ascertain how many clinicians provided information to patients regarding the survey, or posted the printed advertisement provided to all COA members by email. Although reminders were sent to physicians via the COA email distribution list requesting both direct participation in the study and assistance with patient recruitment, direct follow up with physicians was not possible given the magnitude of members and lack of direct access to the addresses by the principal investigator. As the study was dependent on patient recruitment, a lack of relevance to clinical practice amongst contacted members in the study topic may have had a direct impact on low patient numbers. Additionally, this survey attempted to recruit participants through the use of online blog spots. This innovative approach to internet-mediated technology for data collection in quantitative research has not been previously reported in exploring patient reported outcomes following ACLR. Future studies may serve well to explore the feasibility of this method of data collection prior to larger scale research.

Demographically, patients in this study ranged from 15 to 50 years of age. The incidence of ACL injuries in young athletes is highest, with studies typically reporting injury rates among high school and college level athletes. The Multicentre Orthopaedic Outcomes Network (MOON), a multicentre prospective cohort study of patients undergoing ACLR has been tracking the demographics and outcomes of ACLR since its inception in 2002 (Magnussen et al., 2010; Wright et al., 2011). A study published in 2010 by the MOON consortium reported a male population of 52%, with a median age of 23 years of age (Magnussen et al., 2010). A similar Swedish surgical registry reports the main ACL injury at-risk group to be athletes 16-39 years of age. In a study of revision ACLR patients in the MOON cohort, Wright et al., (2011) reported a median age of 22 years of age, ranging from 16 to 49 years of age. The study consisted of 55% male patients compared with 33% in the current study. While the mean age of respondents in this study (38 years) is higher than values typically reported in large scale ACLR studies, the age range is similar to that seen in the 2011 MOON study. The high rate of patients reporting revision ACLR in this study should be noted in analyzing results, since revision ACLR is associated with poorer patient outcomes. In interpreting the results of this study, it is important for individual clinicians to evaluate how applicable the data are to their individual patient population. The broad age range seen here is likely more representative of the general population; however, its distribution across a small sample size makes it difficult to interpret the results with confidence. Furthermore, age differences may be responsible for non-physical reasons for an inability to RTS following surgery. Younger athletes frequently have an increased opportunity to train and compete at a higher level of sport with involvement on a high school or university team. Upon graduation, athletes may find fewer opportunities for athletic involvement. Additionally, recreational and club level teams for adults typically represent a lower level of sports participation, thus lowering the need for high biomechanical stability of the knee. Thus, older athletes may opt for non-surgical management of an ACL deficient knee, biasing the inclusion of a younger population in ACLR studies. Furthermore, adults, faced with increased responsibilities of career and family may find limited time to participate in competitive sports, again, lowering their risk for ACL injury, and need for reconstruction. Their subsequent desire to return to a pre-injury level of sport and definition of success following ACLR may differ from that of younger athletes.

As a consequence of our low patient response, we had low precision in our estimates of patient preferences; and generalizability is compromised. Several strategies may improve patient sampling numbers in future studies. Although surgeons were requested to display a poster in their clinic advertising patient enrollment in the study, direct follow up with all surgeons was not possible in order to ensure compliance with the request. Future personal contact may improve the willingness of surgeons to participate in the study. Similarly, enrolling the assistance of surgeons and multidisciplinary treatment centres to distribute the survey as part of routine follow up at 6 and 12 months post surgery may result a greater number of respondents. Given the high ACL injury rates among young adults, recreational and club teams in high risk sports might prove to be a rich source of potential respondents. Access to this sample population may be achieved through division or league email distribution lists. Additionally, a broader distribution of the survey to members of intercollegiate sports teams across multiple Canadian universities may assist in patient recruitment. Finally, increasing the time frame of sampling may have generated greater response numbers for all subject groups.

Despite a mixed method of recruiting patients through clinician advertising and online posting on various blog sites dedicated to recovery after ACLR, enrollment remained difficult. These findings suggest that online recruitment has inherent limitations and is perhaps problematic for contacting patients. While web based surveys have the potential to be a promising resource as a means for wide survey distribution, and low cost method for collecting data, improved methodology in the context of patient recruitment and survey advertising must be developed in order to achieve meaningful and sufficient numbers of participants.

Several limitations need to be considered when analyzing the results of this study. The major limitation of the study was the low number of patient respondents. As such, only general trends may be identified. Given the nature of self-enrollment of participants in the study, it is possible that the nature of respondents who completed the study may be different than those who did not. Demographic analysis of the data revealed several differences between individuals. The major difference in results was the greater proportion of females than males, and the higher mean age of respondents. However, since gender has not been associated with RTS rates following ACLR, the gender differences in responders may not have contributed to bias in RTS rates in this study. RTS rates in this study were lower than those published in previous studies. When compared with studies distinguishing between levels of sporting participation, these results are more in line with previous reports of return to competitive sport for athletes following ACLR. The lower rate of return to pre-injury level of sport demonstrated in these results is more likely indicative of the higher representation of older athletes, and those who had undergone revision ACLR. With respect to patient reported satisfaction with their knee following ACLR, variables other than difference in level of sporting activity may have contributed to level of satisfaction and be a confounding variable in the measurement. Additionally, patients were asked to choose from provided definitions of success following ACLR. An open-ended qualitative method may have provided valuable patient-defined criteria for success unaccounted for in the patient questionnaire.

However, the unanimous agreement between respondents of success being defined as both functional stability and return to pre-injury level of sport without limitations, suggests alignment of the questions with patient perceived importance.

3.5 Conclusion

A more robust examination of the variables contributing to level of patient satisfaction would be accomplished by the use of a multivariate analysis which included clinician based measures of impairment and performance based measures, in addition to the patient reported questionnaires and measure of kinesiophobia employed in this study. Prospective studies are needed to determine whether patient satisfaction with outcome measures following ACLR is associated with predefined expectations on all levels of the ICF. As such this study should be considered hypothesis generating and provide direction for areas needing future investigation.

REFERENCES

1. Alentorn-Geli, E., Myer, G., Silvers, H., Samitier, G., Romero, D., Lázaro-Haro, C., and Cugat, R. (2009). Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. *Knee Surgery, Sports Traumatology, Arthroscopy,* 17(7),705-729
2. Ardern, C. L., Taylor, N. F., Feller, J. A., & Webster, K. E. (2012). Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *The American Journal of Sports Medicine, 40*(1), 41-48.
3. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to sport following anterior cruciate ligament reconstruction surgery: A systematic review and meta-analysis of the state of play. *British Journal of Sports Medicine, 45*(7), 596-606.
4. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery two-thirds of patients have not returned by 12 months after surgery. *The American Journal of Sports Medicine, 39*(3), 538-543.
5. Barber-Westin, S. D., & Noyes, F. R. (2011). Factors used to determine return to unrestricted sports activities after anterior cruciate ligament

reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 27*(12), 1697-1705.

6. Barber-Westin, S. D., & Noyes, F. R. (2013). Reducing the risk of a reinjury following ACL reconstruction: What factors should be used to allow unrestricted return to sports activities? *The ACL-deficient knee* (pp. 343-355) Springer.
7. Barber-Westin, S. D., & Noyes, F. R. (2011). Objective criteria for return to athletics after anterior cruciate ligament reconstruction and subsequent reinjury rates: A systematic review. *The Physician and Sportsmedicine, 39*(3), 100-110. doi: 10.3810/psm.2011.09.1926; 10.3810/psm.2011.09.1926
8. Birmingham, T.B., Kramer, J.F., Kirkley, A., Inglis, J.T., Spaulding, S.J., & Vandervoort, A.A. (2001). Knee bracing after ACL reconstruction: effects on postural control and proprioception. *Medicine and Science in Sports and Exercise*, 33(8), 1253-1258.
9. Briggs, K. K., Lysholm, J., Tegner, Y., Rodkey, W. G., Kocher, M. S., & Steadman, J. R. (2009). The reliability, validity, and responsiveness of the lysholm score and tegner activity scale for anterior cruciate ligament injuries of the knee 25 years later. *The American Journal of Sports Medicine, 37*(5), 890-897.

10. Dillman, D.A., Smyth, J.D., & Christian, L.M. (2009). *Internet, mail, and mixed-mode surveys. The tailored design method* (3rd ed.) Hoboken: John Wiley & Sons.
11. Dugan, S. A. (2005). Sports-related knee injuries in female athletes: What gives? *American Journal of Physical Medicine & Rehabilitation, 84*(2), 122-130.
12. Eastlack, M.E., Axe, M.J., and Snyder-Mackler, L. (1999). Laxity, instability, and functional outcome after ACL injury: copers versus noncopers. *Medicine and Science in Sports and Exercise*, 31(2):210-215.
13. Feller, J., & Webster, K. E. (2013). Return to sport following anterior cruciate ligament reconstruction. *International Orthopaedics, 37*(2), 285-290.
14. Fitzgerald, G., Axe, M., & Snyder-Mackler, L. (2000). A decision-making scheme for returning patients to high-level activity with nonoperative treatment after anterior cruciate ligament rupture. *Knee Surgery, Sports Traumatology, Arthroscopy, 8*(2), 76-82.
15. Gilchrist, J., Mandelbaum, B. R., Melancon, H., Ryan, G. W., Silvers, H. J., Griffin, L. Y., . . . Dvorak, J. (2008). A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *The American Journal of Sports Medicine, 36*(8), 1476-1483.

16. Gissane, C., White, J., Kerr, K., & Jennings, D. (2001). An operational model to investigate contact sports injuries. *Medicine and Science in Sports and Exercise, 33*(12), 1999-2003.

17. Gobbi, A., & Francisco, R. (2006). Factors affecting return to sports after anterior cruciate ligament reconstruction with patellar tendon and hamstring graft: A prospective clinical investigation. *Knee Surgery, Sports Traumatology, Arthroscopy, 14*(10), 1021-1028.

18. Heijne, A., Axelsson, K., Werner, S., & Biguet, G. (2008). Rehabilitation and recovery after anterior cruciate ligament reconstruction: Patients' experiences. *Scandinavian Journal of Medicine & Science in Sports, 18*(3), 325-335.

19. Hewett, T. E., Di Stasi, S. L., & Myer, G. D. (2013). Current concepts for injury prevention in athletes after anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine, 41*(1), 216-224.

20. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.

21. Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Colosimo, A. J., McLean, S. G., . . . Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior

cruciate ligament injury risk in female athletes A prospective study. *The American Journal of Sports Medicine, 33*(4), 492-501.

22. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.
23. Hewett, T. E., Myer, G. D., & Ford, K. R. (2006). Anterior cruciate ligament injuries in female athletes part 1, mechanisms and risk factors. *The American Journal of Sports Medicine, 34*(2), 299-311.
24. Irrgang, J.J. (2008). Current status of measuring clinical outcomes after anterior cruciate ligament reconstruction: are we good enough? *Operative Techniques in Sports Medicine*, 16, 119-124.
25. Jette, D.U., Halbert, J., Iverson, C., Miceli, E., and Shah, P. (2009). Use of standardized outcome measures in physical therapist practice: perceptions and applications. *Physical Therapy*, 89(2), 125-135.
26. Kaplowitz, M.D., Lupi, R., Couper, M.P., and Thorp, L. (2012). The Effect of Invitation Design on Web Survey Response Rates. *Social Science Computer Review*, 30(3),339-349.
27. Kartus, J., Stener, S., Köhler, K., Sernert, N., Eriksson, B. I., & Karlsson, J. (1997). Is bracing after anterior cruciate ligament reconstruction necessary? A 2-year follow-up of 78 consecutive patients rehabilitated with

or without a brace. *Knee Surgery, Sports Traumatology, Arthroscopy*, *5*(3), 157-161.

28. Kennedy, D.M., Robarts, S., & Woodhouse, L. (2010). Patients are satisfied with advanced practice physiotherapists in a role traditionally performed by orthopaedic surgeons. *Physiotherapy Canada*, 62(4), 298-305.

29. Keusch, F. (2012). How to Increase Response Rates in List-Based Web Survey Samples. *Social Science Computer Review*, 30(3):380-388.

30. Kocher, M. S., Steadman, J. R., Briggs, K., Zurakowski, D., Sterett, W. I., & Hawkins, R. J. (2002). Determinants of patient satisfaction with outcome after anterior cruciate ligament reconstruction. *The Journal of Bone & Joint Surgery*, *84*(9), 1560-1572.

31. Kvist, J., Ek, A., Sporrstedt, K., & Good, L. (2005). Fear of re-injury: A hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 13*(5), 393-397.

32. Laboute, E., Savalli, L., Puig, P., Trouve, P., Sabot, G., Monnier, G., & Dubroca, B. (2010). Analysis of return to competition and repeat rupture for 298 anterior cruciate ligament reconstructions with patellar or hamstring tendon autograft in sportspeople. *Annals of Physical and Rehabilitation Medicine*, 53, 598-614.

33. Langford, J. L., Webster, K. E., & Feller, J. A. (2009). A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine, 43*(5), 377-378.

34. Leece, P., Bhandari, M, Sprague, S., Swiontkowski, M.F., Schemitsch, M.H., Tornetta III,P.,…& Guyatt, H. (2004). Internet versus mailed questionnaires: a controlled comparison (2). Journal of medical Internet research 6(4).

35. Lentz, T. A., Tillman, S. M., Indelicato, P. A., Moser, M. W., George, S. Z., & Chmielewski, T. L. (2009). Factors associated with function after anterior cruciate ligament reconstruction. *Sports Health: A Multidisciplinary Approach, 1*(1), 47-53.

36. Lephart, S. M., Abt, J. P., & Ferris, C. M. (2002). Neuromuscular contributions to anterior cruciate ligament injuries in females. *Current Opinion in Rheumatology, 14*(2), 168-173.

37. Lephart, S. M., Perrin, D., Fu, F., Gieck, J., McCue, F., & Irrgang, J. (1992). Relationship between Selected Physical Characteristics and Functional Capacity in the Anterior Cruciate Ligament Insufficient Individual, *Journal of Orthopaedic and Sports Physical Therapy, 16(4), 174-181.*

38. Leung, W.C. (2001). How to Design a Questionnaire. *Student British Medical Journal*, 9:187-189.

39. Lewek, M.D., Chmielewski, T.L., Risberg, M.A., & Snyder-Mackler, L. (2003). Dynamic knee stability after anterior cruciater ligament rupture. *Exercise and sport sciences reviews*, 31(4), 195-200.

40. Magnussen, R. A., Granan, L. P., Dunn, W. R., Amendola, A., Andrish, J. T., Brophy, R., ... & Engebretsen, L. (2010). Cross-cultural comparison of patients undergoing ACL reconstruction in the United States and Norway. *Knee Surgery, Sports Traumatology, Arthroscopy*, *18*(1), 98-105.

41. Manal, T. J., & Snyder-Mackler, L. (1996). Practice guidelines for anterior cruciate ligament rehabilitation: A criterion-based rehabilitation progression. *Operative Techniques in Orthopaedics, 6*(3), 190-196.

42. Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y., . . . Garrett, W. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes 2-year follow-up. *The American Journal of Sports Medicine, 33*(7), 1003-1010.

43. Marx, R. G., Stump, T. J., Jones, E. C., Wickiewicz, T. L., & Warren, R. F. (2001). Development and evaluation of an activity rating scale for disorders of the knee. *The American Journal of Sports Medicine, 29*(2), 213-218.

44. McDevitt, E.R., Taylor, D.C., Miller, M.D., Gerber, J.P., Ziemke, G., Hinkin, D., …& Pierre, P.S. (2004). Functional bracing after anterior cruciate

ligament reconstruction: A prospective, randomized, multicentre study. *The American journal of sports medicine*, 32(8), 1887-1892.

45. Möller, E., Forssblad, M., Hansson, L., Wange, P., & Weidenhielm, L. (2001). Bracing versus nonbracing in rehabilitation after anterior cruciate ligament reconstruction: a randomized prospective study with 2-year follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *9*(2), 102-108.
46. Myklebust, G., & Bahr, R. (2005). Return to play guidelines after anterior cruciate ligament surgery. *British Journal of Sports Medicine, 39*(3), 127-131.
47. Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., . . . Krosshaug, T. (2008). Non-contact ACL injuries in female athletes: An international olympic committee current concepts statement. *British Journal of Sports Medicine, 42*(6), 394-412.
48. Risberg, M. A., Beynnon, B. D., Peura, G. D., & Uh, B. S. (1999). Proprioception after anterior cruciate ligament reconstruction with and without bracing. *Knee Surgery, Sports Traumatology, Arthroscopy*, *7*(5), 303-309.
49. Ross, M. D., Irrgang, J. J., Denegar, C. R., McCloy, C. M., & Unangst, E. T. (2002). The relationship between participation restrictions and selected clinical measures following anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 10*(1), 10-19.

50. Shaw, T., Chipchase, L. S., & Williams, M. T. (2004). A users guide to outcome measurement following ACL reconstruction. *Physical Therapy in Sport, 5*(2), 57-67.

51. Shi,T., and Fan. X. (2008). Comparing Response Rates from Web and Mail Surveys: A Meta-Analysis. *Field Methods*, 20(3), 249-271. doi: 10.1177/1525822X08317085

52. Shimokochi, Y., & Shultz, S. J. (2008). Mechanisms of noncontact anterior cruciate ligament injury. *Journal of Athletic Training, 43*(4), 396.

53. Smith, F., Rosenlund, E., Aune, A., MacLean, J., & Hillis, S. (2004). Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine, 38*(3), 279-284.

54. Snyder-Mackler, L., Fitzgerald, G.K., Bartolozzi, A.R., and Ciccotti, M.G. (1997). The relationship between passive joint laxity and functional outcome after anterior cruciate ligament injury. *American Journal of Sports Medicine*, 25(2), 191-195.

55. Spindler, K. P., Huston, L. J., Wright, R. W., Kaeding, C. C., Marx, R. G., Amendola, A., . . . Harrell, F. E. (2011). The prognosis and predictors of sports function and activity at minimum 6 years after anterior cruciate ligament reconstruction A population cohort study. *The American Journal of Sports Medicine, 39*(2), 348-359.

56. Tegner, Y., & Lysholm, J. (1985). Rating systems in the evaluation of knee ligament injuries. *Clinical Orthopaedics and Related Research, 198*, 42-49.

57. Thompson, A. G., & Sunol, R. (1995). Expectations as determinants of patient satisfaction: concepts, theory and evidence. *International Journal for Quality in Health Care*, *7*(2), 127-141.

58. Vicente, P., and Reis, E. (201*0).* Using Questionnaire Design to Fight Nonresponse Bias in Web Surveys. *Social Science Computer Review*, 28(2):251-267.

59. Webster, K. E., Feller, J. A., & Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Physical Therapy in Sport, 9*(1), 9-15.

60. Williams, G. N., Taylor, D. C., Gangel, T. J., Uhorchak, J. M., & Arciero, R. A. (2000). Comparison of the single assessment numeric evaluation method and the Lysholm score. *Clinical Orthopaedics and Related Research, 373*, 184-192.

61. Woolley, F. R., Kane, R. L., Hughes, C. C., & Wright, D. D. (1978). The effects of doctor-patient communication on satisfaction and outcome of care. *Social Science & Medicine. Part A: Medical Psychology & Medical Sociology*, *12*, 123-128.

62. Wright, R.W., & Fetzer, G.B. (2007). Bracing after ACL reconstruction: a systematic review. *Clinical orthopaedics and related research*, 455, 162-168.

63. Wright, R., Spindler, K., Huston, L., Amendola, A., Andrish, J., Brophy, R., ... & Dunn, W. (2011). Revision ACL reconstruction outcomes: MOON cohort. *Journal of Knee Surgery*, *24*(04), 289-294.

64. Wu, G. K., Ng, G. Y., & Mak, A. F. (2001). Effects of knee bracing on the sensorimotor function of subjects with anterior cruciate ligament reconstruction. *The American journal of sports medicine*, *29*(5), 641-645.

65. Zebis, M. K., Andersen, L. L., Bencke, J., Kjær, M., & Aagaard, P. (2009). Identification of athletes at future risk of anterior cruciate ligament ruptures by neuromuscular screening. *The American Journal of Sports Medicine, 37*(10), 1967-1973.

CHAPTER 4

A SURVEY OF THE DECISION MAKING PROCESS FOR RTS FOLLOWING ACLR: A COMPARISON BETWEEN ORTHOPAEDIC SURGEONS AND PHYSIOTHERAPISTS

ABSTRACT

Objective: To perform an environmental survey of clinical practice of surgeons and physiotherapists of the decision making process in RTS following ACLR; and to gain a better understanding of how clinicians define successful RTS.

Design: Multidisciplinary cross sectional study.

Setting: Online

Participants: Orthopaedic surgeons and registered physiotherapists

Interventions: Surgeons and physiotherapists completed separate web surveys which each consisted of 10 closed format questions that included sections on demographics, outcome measures, treatment procedures, and RTS decisions.

Main Outcome Measures: Descriptive and subjective data were collected for orthopaedic surgeons and physiotherapists. Use of clinical outcome measures by both groups were analyzed qualitatively for similarities between professions, and with recently proposed consensus criteria used to decide RTS readiness. Level of agreement for definition of successful RTS following ACLR was explored through frequency of item response.

Results: Responses were obtained from 83 orthopaedic surgeons, and 73 registered physiotherapists. Overall, the majority of clinician respondents favoured impairment based measures over function and activity based measures. Surgeons and physiotherapists reported similar use of jump tests, ROM, Lachman clinical test of stability, pain, swelling, and functional movement as contributing to their RTS decisions. Subjective reports of giving way contributed to RTS decision making among surgeons, but not among physiotherapists. Patient reported outcome measures did not contribute strongly to RTS decision making between either group of respondents. Physiotherapists overwhelmingly expressed a high level of confidence (98%) that there is a role for physiotherapists in making the primary return to sport decision following ACLR. No consensus was reached for a single definition of successful return to sport following ACLR by either group.

Conclusions: Orthopaedic surgeons and physiotherapists reported the similar use of clinical outcome measures and PROs to determine RTS readiness in athletes following ACLR. Clinicians favoured the use of impairment based measures at the expense of self-reported measures of function, activity, and participation.

Clinical Relevance: Well established, reliable and validated outcome measures at all levels of the ICF are not being used consistently by Canadian clinicians in determining RTS readiness in athletes following ACLR.

Key Words: ACL reconstruction, knee injury, return to sport, outcome measures

4.1 Introduction

ACLR is considered the gold standard for restoring normal biomechanics and functional stability of the knee after injury. Athletes wishing to return to competition frequently pursue surgical reconstruction of an ACL deficient knee with the belief that it will restore their ability to participate in a high level of sport. However, a significant number of athletes are unable to return to their pre-injury level of sporting activity following ACLR, despite performing well on functional outcome measures. A myriad of tests exist to assess impairment, function, and participation in patients after ACLR. However, currently, little consensus exists on which outcome measures best evaluate an athlete's RTS readiness, and no standardized clinical guidelines exist to assist clinicians in making RTS decisions. RTS rates vary, with rates as low as 33% for athletes resuming a competitive level of sport (Ardern et al., 2011).

Despite the ACLR being the gold standard for management of an athlete with an ACL rupture, significant controversy still exists regarding the best choice of graft. Currently, no evidence-based consensus exists to aid clinical decision making. BPTB autograft has typically been the dominant choice of graft due to the inherent strength of the tissue, the relative ease of harvest, and good bone-bone healing (Reinhardt et al., 2010). Concerns of anterior knee pain and disruption of the knee extensor mechanism following use of a BPTB graft have increased interest in the use of HT as the graft of choice for ACLR.

Research into comparisons of graft choice have focused on graft harvest site morbidity, functional strength, clinical tests of laxity, return to sport, and standardized functional and patient reported outcome measures (Reinhardt et al., 2010). Reinhardt et al. (2010) further highlight the short term measure of functional stability and the long term risk of OA as the most important criteria for evaluating the superiority of one graft over another. In a 10 year follow up of patients post ACLR, Holm et al. (2010) found no statistically significant difference in either functional outcome (CKRS, single leg hop tests, pain, muscle strength, or joint laxity) or prevalence of osteoarthritis of the operated knee. Similarly, although rates of OA in the operated knee were slightly higher in HT versus BPTB groups following ACLR, at 55% and 64% of patients respectively, this was not shown to be statistically significant (p=0.27) (Reinhardt et al., 2010). Prevalence of OA in the corresponding uninvolved knee was substantially lower, at 28% and 22%. In a systematic review of Level I and II studies of outcomes following ACLR, Foster et al. (2010) found equivalence between autograft and allograft selection on several measures. In a meta-analysis of pooled results, no statistically significant difference was found between pivot-shift results, IKDC scores, Lysholm scores, and postoperative complications. Additionally, no statistically significant difference was found between groups with respect to instrumented laxity of 3 or 5 mm as measured with the KT-1000. Although graft failure rates were higher for allograft repairs (8.2 ± 2.1) than autograft repairs (4.7 ± 0.5) per 100 ACLRs, this was not found to be statistically significant (t = 1.49, p>0.1). This suggests that the choice of graft selection should be individualized according to the treating surgeon, concerns with donor site morbidity, and the functional needs of the patient

Further evidence is needed to determine whether the inability of graft selection to demonstrate a difference in outcome following ACLR is due to a lack of superiority of one graft over another, or a lack of sensitivity of current outcome measures to identify successful RTS readiness. Gobbi and Fransicso (2006) prospectively compared the RTS status of an equal number of athletes (n=100) who underwent ACLR using either BPTB or HT grafts. Data were gathered pre-operatively, and at 3, 6, 12 and 24 months following ACLR using the IKDC, Lysholm score, Noyes, and Tegner scales. Objective evaluation involved measurement of isokinetic strength, and computerized laxity test. Subjective assessment was measured by the Marx Knee Activity scale, SANE, and a psychological profile questionnaire. At 24 months, two-thirds of the athletes had returned to their pre-injury level of sport. One quarter of patients returned to a lower level of sports, whereas 11% ceased sport activities. Of those patients who returned to their pre-injury level of sport, no statistically significant difference was seen between choice of graft. Similarly, no significant difference in IKDC, Lysholm, Noyes and Tegner scores was found between graft types. Furthermore, the same rating scales were unable to differentiate between athletes who had returned to their pre-injury level of sport compared with those who had returned to a lower level. Likewise, a comparison of athletes who had returned to a lower level of sport activity with those who had ceased sports participation revealed no significant differences in IKDC, Lysholm, Noyes or Tegner scores. Only the Marx Knee Activity scores and psychovitality questionnaire were able to differentiate between athletes who were able to return to their pre-injury level of sport and those who were not. The IKDC, Lysholm, Noyes and Tegner scales remain well validated, commonly used measures of evaluating recovery following ACLR. Additional measures may be influential in identifying those athletes who are able to successfully return to their pre-injury level of sport following reconstruction of their ACL.

Given high ACLR failure rates, and the associated poor long term health of the knee following a repeat ACL injury, RTS decisions need to be founded on evidence supported outcome measures. A more comprehensive understanding of current clinical decision making is the first critical step in establishing any gaps in evidence based practice. The purposes of this study were to (1) perform an environmental survey of clinical practice amongst surgeons and physiotherapists in Canada in making RTS decisions following ACLR, and (2) to gain a better understanding of how clinicians define successful RTS.

4.2 Methods

4.2.1 Survey development

Subjective questions were developed after a thorough literature review and consultation with experts to gain better understanding of subjective factors fundamental in determining RTS status of an athlete after ACLR. Standardized outcome measures used were chosen for their simplicity of use, validation on an ACL population, reliability, cost and time effectiveness, and applicability to decision making. Furthermore, exploratory questions were posed to surgeons and physiotherapists to examine initial support for the concept of potentially expanding the role of physiotherapists in post surgical decision making, establishing a basis for future research.

Questionnaires designed for surgeons and physiotherapists were each respectively comprised of 10 closed-ended questions that include sections on demographics, outcome measures, treatment procedures, and RTS decisions. Dillman's Tailored Design Method is considered the current standard for designing mail and internet surveys. In accordance with their principles, sampling methods and a respondent friendly design were employed to increase respondent participation (Dillman et al., 2009). The web surveys were designed to minimize non-response rates and any associated potential bias (Kaplowitz et al., 2012, Keusch, 2012, Leung, 2001, and Vicente & Reis, 2010). In order to minimize the burden on participants, the survey was designed to be brief and easy to complete. A screen design was employed; questionnaires were limited to fewer than 20 questions, radio button formatting and drop down menus were employed, a priori announcement of questionnaire length was given, and a progress indicator illustrated completion rate.

4.2.2 Survey administration

Sampling frames for orthopaedic surgeons and physiotherapists across Canada were limited by the number of members on the distribution list held by the Canadian Orthopaedic Association (COA) and the Canadian Physiotherapy Association (CPA), respectively. Approximately 1000 COA and 10 000 CPA members were accessed through this method. Mass electronic mailings versus random sampling were chosen to maximize the number of clinicians contacted and increase the generalizability of results. Both groups received 3 electronic contacts: an initial invitation to participate and two follow up requests. The first follow up request was sent out 2 weeks after the initial contact, followed by a third follow up email approximately 3 weeks later.

4.2.2.1 Orthopaedic Surgeons

Participants were recruited primarily through an email distribution list to surgical residents, fellows, and orthopaedic surgeons nation-wide via the COA. Additionally, details of the study were orally presented to members of the COA at a national Annual General Meeting (AGM). Demographic and subjective information collected for surgeons included their experience performing ACLR, primary choice of graft, use of standardized rehab protocol and bracing, use of outcome measures in determining RTS readiness, ACLR failure rates, level of endorsement for proposed definitions of successful RTS, and their opinion about the potential role of physiotherapists in making primary RTS decisions (Survey questionnaire presented in Appendix M).

4.2.2.2 Physiotherapists

Participants were recruited nationwide via email distribution lists through the CPA and its orthopaedic and sports divisions. Demographic and subjective information collected for physiotherapists included their level of education and clinical experience, use of standardized rehab protocols and outcome measures, level of endorsement for proposed definitions of successful return to sport, level of agreement with surgeons on RTS readiness, and their opinion about the potential role of physiotherapists in making primary RTS decisions (Survey questionnaire presented in Appendix J).

4.2.3 Protocol

Raw data was collected anonymously and stored online using secure technology to encrypt the online survey and response information. No personally identifiable information was collected. Access to the data was further secured through the use of a password protected web account. Aggregate data was stored on a personal computer protected by a password, and stored in a locked room. The principal investigator collected and analyzed all data.

4.2.4 Ethical Consideration

Access to the web survey was restricted to subjects who agreed to consent to their participation online through a checkbox at the top of the questionnaire. A link to the consent form was provided which described the purpose of the study and role of the subjects. Ethical approval was provided by Hamilton Integrated Research Ethics Board and the University of Toronto Research Ethics Board.

4.2.5 Data Analysis

Statistical analyses were conducted with SPSS for Windows Version 21.0 (SPSS Inc, Chicago, IL). Descriptive statistics were generated for all demographic data, outcome measures used, RTS decisions, and definitions of success. Outcome measures used by clinicians were analyzed for the proportion of surgeons and physiotherapists using each measure on a nominal scale, using the descriptors 'do not use', 'use, but does not contribute to RTS decision' and 'contributes to RTS decision'. Outcome measures which clinicians reported as contributing to RTS decisions where interpreted as foundational in current clinical practice patterns. RTS decisions were analyzed for the proportion of clinicians who felt there is a role for physiotherapists in making the primary RTS decision following ACLR. Support for the concept will be expressed as a summed percentage of agreement using the equation (Agree + APP) ÷Disagree x 100 = %Support.

A frequency analysis of pre-defined definitions of successful RTS following ACLR was also performed. Definitions of success are reported as percentages of respondents' agreement with previously reported patient defined criteria of functional stability, and return to pre-injury level of sport with no limitations.

4.3 Results

4.3.1Demographic Data

4.3.1.1Surgeons

A total of 83 orthopaedic surgeons, all with more than 15 years of experience performing ACLR, participated in this study. Demographic information for these respondents is presented in Table 4.1.

Table 4.1 Demographic and Subjective Data for Surgeons

Demographics	n	%
Number of years performing ACLR		
15-19	11	13.3
20+	19	22.9
Missing values	50	60.2
Number of Primary ACLR performed per year		
0-24	34	41.0
25-49	19	22.9
50-99	15	18.1
100+	9	10.8
Missing values	6	7.2
% Patients requiring revision following primary ACLR		
0-4	37	44.6
5-9	22	26.5
10-14	6	7.2
15-19	1	1.2
Missing values	17	20.4

4.3.1.2 Physiotherapists

A total of 73 physiotherapists were included in this study. Likewise, at the time of the survey all respondents had been practicing clinically for at least 15 years, with a designation of FCAMT/MScCl most frequently cited as the highest level of qualification. Demographic information for physiotherapists is presented in Table 4.2.

Table 4.2 Demographic data for Physiotherapists

Demographics	**Percentage**
Number of years practicing as a PT	
15-19	15.1
20-24	9.6
25+	11.0
Number of ACL patients treated per year	
0-4	23.3
15-19	5.5
20-24	2.7
25+	6.8
Professional qualifications attained (no.)	
BScPT/MScPT	1.4
MSc	9.6
FCAMT/MScCl	23.3
APP	1.4

4.3.2 Primary Graft Choice

Use of a hamstring graft was the most popular technique cited at 79.5%, followed by use of a patellar tendon graft (12%). At 2.4%, use of an allograft as the primary choice of graft represented a significant minority of cases. Six point one percent of orthopaedic surgeons did not respond to the question.

4.3.3 Outcome Measures Used

4.3.3.1 Orthopaedic Surgeons

A comparison of outcome measures used by orthopaedic surgeons and physiotherapists is displayed in Figure 4.1. Overall, the majority of surgeons reported that jump tests, ROM, Lachman clinical test of stability, pain, swelling, functional movement and giving way contributed to their RTS decisions. Validated self-report measures played only a minor role in RTS decisions (IKDC Subjective 1.4%, Tegner 0%, Marx Knee Activity Scale 1.4%, and ACL-RSI 5.5%).

4.3.3.2 Physiotherapists

A comparison of outcome measures used by surgeons and physiotherapists is displayed in Figures 4.1 (impairment based) and 4.2 (functional outcome measures). Use of outcome measures by physiotherapists was fairly evenly distributed amongst jump tests (64.4%), ROM (64.4%), subjective reports of pain (65.8%), swelling (67.1%), and functional movement (82.2%). Subjective reports of giving way did not play prominently in contributing to a RTS decision by physiotherapists (8.5%). In line with surgeons' responses, the clinical use of validated self-report measures in their decision making process was minimal (IKDC Subjective 1.4%, Marx Knee Activity Scale 1.4%, ACL-RSI 5.5%, Tegner 0%, and Lysholm 0%).

Figure 4.1 Percentage of surgeons and physiotherapists using impairment based outcome measures to determine RTS readiness

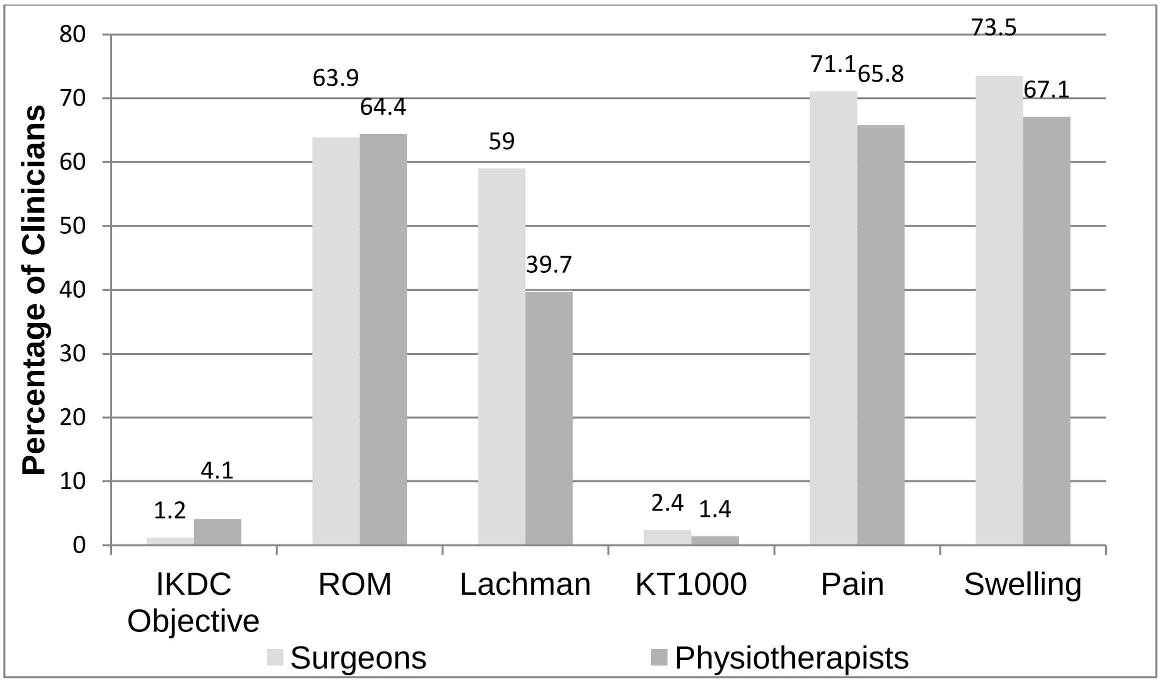
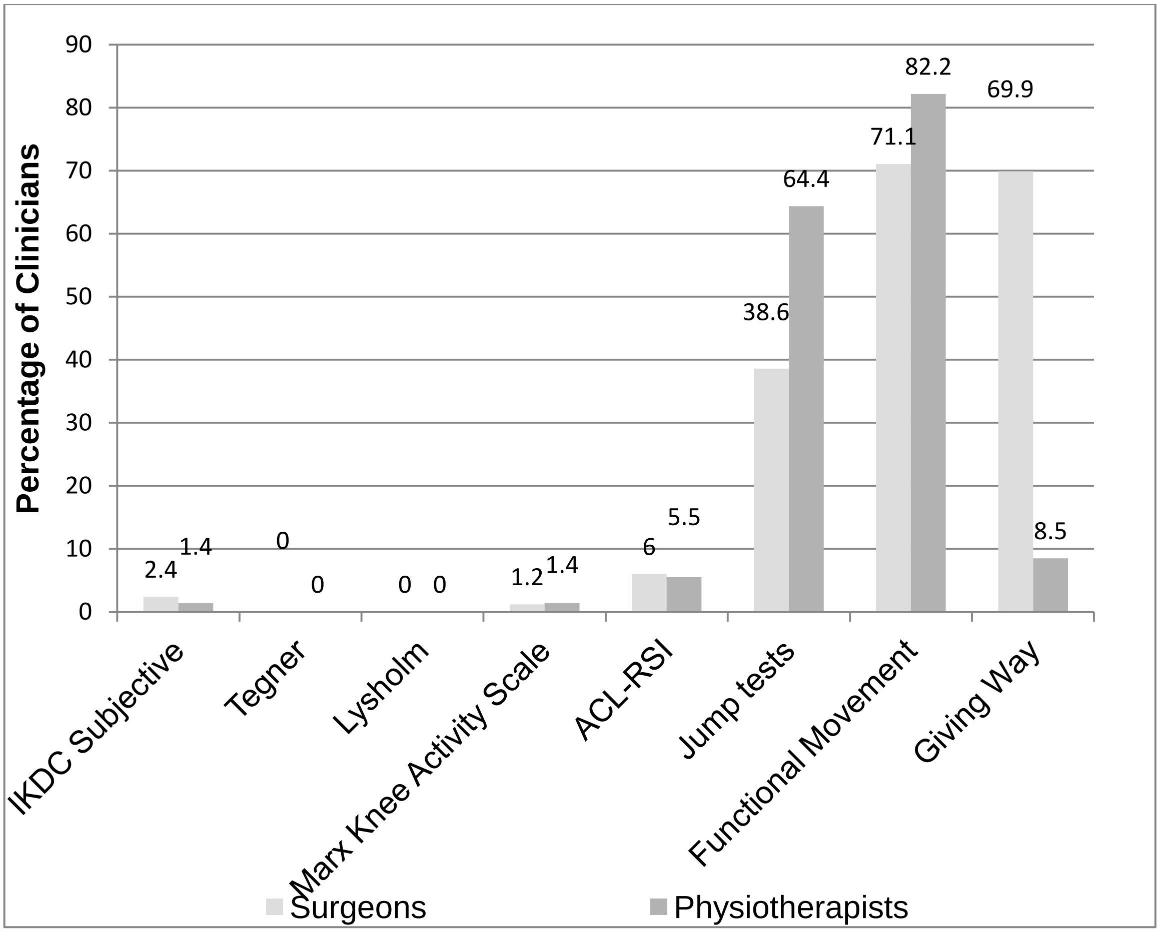


Figure 4.2 Percentage of surgeons and physiotherapists using function and self report outcome measures to determine RTS readiness



4.3.4 Practice Patterns

4.3.4.1 RTS Clearance

Surgeons reported comparable post ACLR timelines for allowing athletes to return to sport for patellar tendon (44.6%) and hamstring graft (45.8%), at a minimum of six months. A more conservative approach was reported following allograft, with 30.1% of surgeons waiting until at least nine months to provide medical clearance prior to allowing sporting participation. Table 4.4 presents the minimal number of months surgeons reported requiring prior to allowing RTS clearance.

Table 4.3 Minimal chronological timeline for RTS clearance

Minimal number of months	Bone patellar-tendon bone graft		Hamstring graft		Allograft	
	n	%	n	%	n	%
3	0	0	3	3.6	1	1.2
4	2	2.4	0	0	0	0
5	3	3.6	2	2.4	0	0
6	37	44.6	38	45.8	13	15.7
9	9	10.8	16	19.3	25	30.1
12+	1	1.2	3	3.6	11	13.3
Missing values	31	37.4	21	25.3	33	39.7

4.3.4.2 Postoperative Bracing

Disagreement was evident between surgeons as to their prescribed use of a functional brace following ACLR, with 42% (n=35) reporting their use. Responses were not specified with respect to type of brace, length of use, or graft choice. Non-response rate was 18% for use of a function brace.

4.3.5 RTS Decision Making

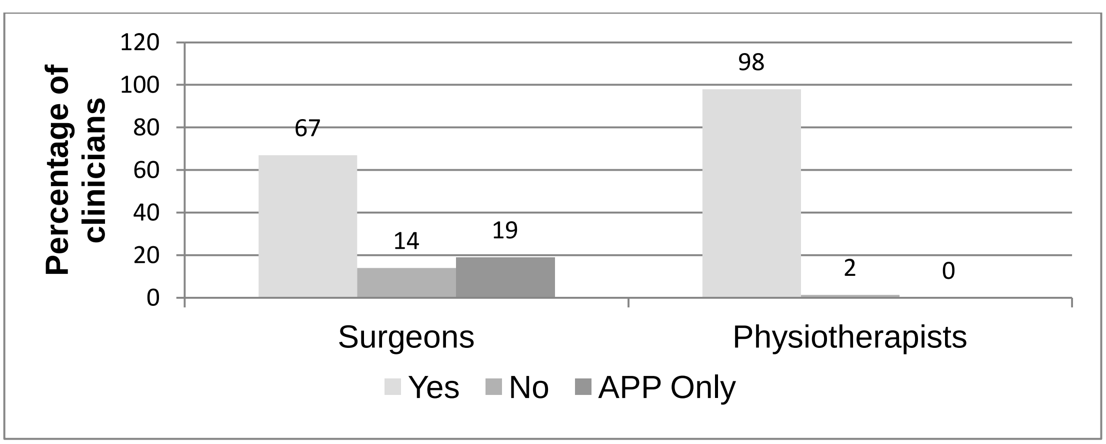
4.3.5.1 Surgeons

With respect to exploring the potential role for physiotherapists in making the primary RTS decision following ACLR, 67% of surgeons supported the idea, while only 14% were against, and 19% favoured Advanced Practice Physiotherapists (APP) providing medical clearance. Expressed as a summed percentage of agreement, 86% of surgeons responded favourably to the concept of involving the physiotherapy profession in RTS decision making.

4.3.5.2 Physiotherapists

Respondents expressed a high level of confidence (98%) that there is a role for physiotherapists in making the primary RTS decision following ACLR. Clinician response to physiotherapy involvement in RTS decision making is presented in Figure 4.3.

Figure 4.3 Percentage of respondents who felt that there is a role for physiotherapists in making the primary RTS decision following ACLR

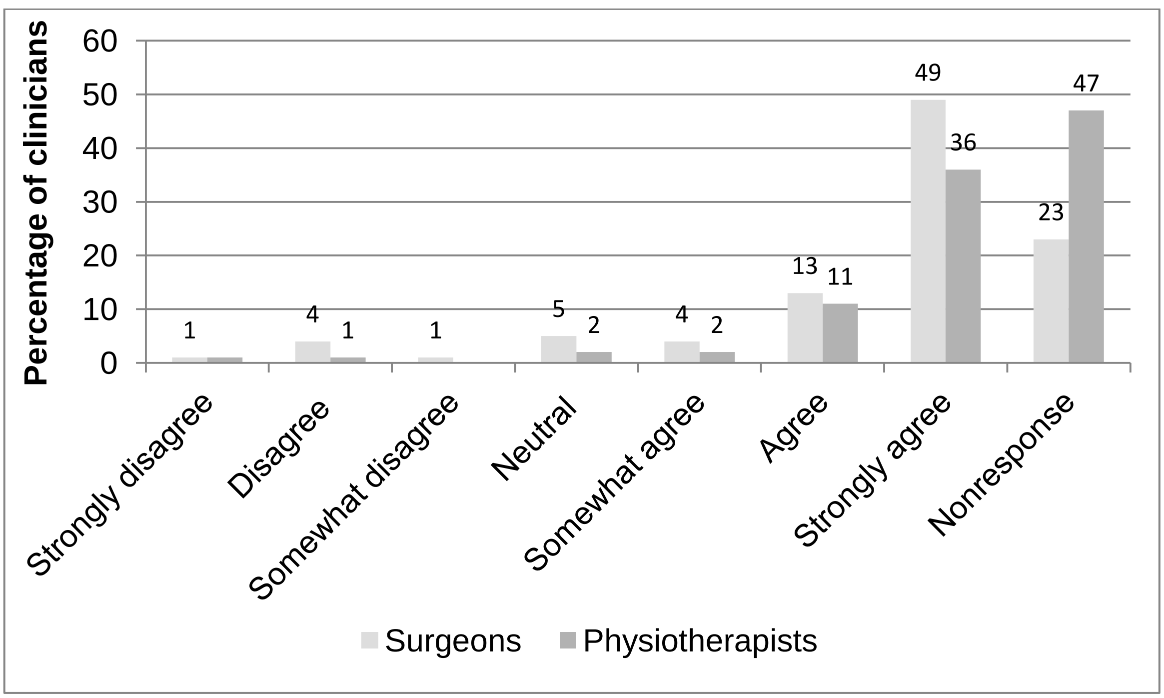


4.3.6 Definition of Successful RTS

4.3.6.1 Functional Stability

When assessed for level of agreement for the definition of functional stability representing successful RTS following ACLR, 49% of orthopaedic surgeons, and 36% of physiotherapists strongly agreed with the statement. Surgeons and physiotherapists agreed with the statement 13% and 11% of the time. Differences between clinicians in level of agreement with definitions of successful RTS following ACLR are presented in Figures 4.4 and 4.5.

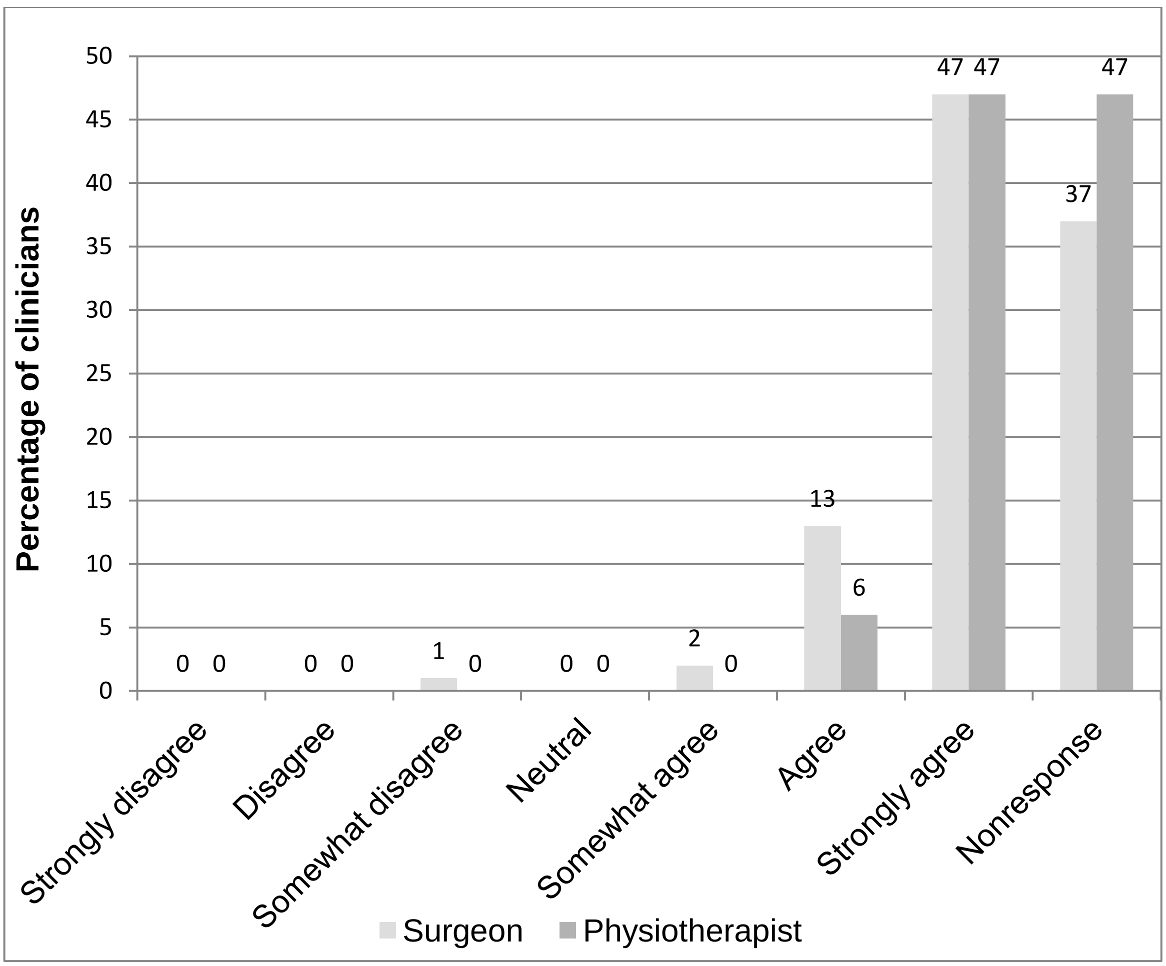
Figure 4.4 Functional stability as a definition of successful RTS following ACLR



4.3.6.2 Return to Pre-injury Level of Sport

Surgeons and physiotherapists expressed a summed agreement with the definition of successful RTS as 'return to pre-injury level of sport with no limitations' 60% and 53% of the time, respectively. Full level of agreement with the statement is presented in Figure 4.5.

Figure 4.5 Return to pre-injury level of sport with no limitations as a definition of successful RTS following ACLR



4.4 Discussion

The objectives of this study were to perform an environmental survey of clinical practice of surgeons and physiotherapists of the decision making process in RTS following ACLR; and to gain a better understanding of how clinicians define successful RTS. Several trends were demonstrated between and within groups. Both surgeons and physiotherapists favoured the use of impairment based measures over self-report measures in determining RTS. However, consensus on the use of the best individual measures was not reached. Both surgeons and physiotherapists demonstrated support for the involvement of physiotherapists in making primary RTS decisions following ACLR. There were subtle but important differences in how both groups defined successful RTS. Finally, the surgeons reported the use of HT as the graft of choice, with controversy surrounding the use of functional bracing.

One of the objectives of the current study was to gain a better understanding of how clinicians define successful RTS. Unanimous consensus existed for the ability to participate in any level of sport as the primary measure of successful RTS following ACL reconstruction. Subtle differences, however, existed between the degrees of level of participation. Surgeons most frequently accepted participation in any level of sport without pain as the definition of success, whereas physiotherapists reported success at a higher level of function, defined as participating in pre-injury level of sport with no limitations or deficits. Both groups agreed on functional stability as their second priority in achieving success post ACLR. Lynch et al. (2013) attempted to establish a professional consensus definition of success following ACLR by surveying members of several international sports medicine associations. Despite being identified by consensus as one of six important measures of successful outcome, return to play (RTP) was not clearly defined in with regards to frequency or type of sport participation. Clearly defined thresholds for success as measured by level of RTS status are necessary to quantify the level of participation according to the ICF. Standardized terminology for successful RTS status would facilitate comparisons between studies, and provide meaningful goals for patient driven rehabilitation.

Orthopaedic surgeons and physiotherapists in this study both employed a minimum of 4 or 5 outcome measures in their determination of medical clearance. This may reflect that none of the measures independently provided a comprehensive assessment, but that a selection of measures may prove to be a more comprehensive assessment. Furthermore, measures of self-reported function, clinical measures of impairment, and performance based measures provide different information. Orthopaedic surgeons and physiotherapists both favoured the use of primarily impairment based, not self-report measures. Barber-Westin and Noyes (2011) proposed criteria for determining RTS readiness, based on a literature search of outcome measures used after primary ACLR. They included limb symmetry index on the single leg hop test, quadriceps strength, lack of pain or effusion, full ROM, functional knee stability, surgical and psychological factors. Lynch et al. (2013) further identified RTS criteria based on international expert consensus to define successful outcome following ACLR. An operational definition of 80% was used to identify consensus. Based on the responses of 1779 members of international sports medicine associations, six criteria were identified as the absence of giving way, patient return to sport status, the absence of knee joint effusion, quadriceps muscle strength symmetry and PROs. While surgeons in the current study reported the use of some of the outcome measures identified by both Barber-Westin and Noyes (2011) and Lynch et al. (2013), assessment of PROs and the absence of giving way were underrepresented in their determination of RTS readiness. Likewise, a measure of RTS status, if interpreted as a measure of sport participation, was neglected in the decision making process of both orthopaedic surgeons and physiotherapists in the current study. Use of the Tegner Activity scale and the Marx Knee Activity scale, which both assess level of sport activity, was reported less than 1.4% of the time. Furthermore, surgeon consensus, as defined as 80% agreement, was not achieved on any measure. Only physiotherapists reached consensus on the use of functional movement as a necessary outcome measure. A disproportionate contribution to decision making may have been placed on the use of the Lachman test to determine clinical A-P laxity of the knee. Structural stability of the knee, while a measure of surgical success, is not a robust enough outcome measure to mimic the demand placed on the ACL during high load cutting and pivoting sports. Despite the use frequently reported measures of self-reported function and activity level investigated in this study, available evidence does not, as yet, seem to have impacted on clinical practice.

Future studies would be needed to determine whether clinician familiarity with individual outcome measures and their respective psychometric properties, ease of use, perceived burden of time to complete and analyze each measure, comprehensiveness of formal training, perceived value of a measure in directing decision making, or personal bias was responsible for reported decision making practices. The lack of a gold standard for identifying a successful outcome following ACLR likely influenced clinicians' choice of outcome measures used.

Fear of re-injury, as measured by the self report outcome measure ACL-RSI, attempts to explore some of the psychological barriers which may influence RTS readiness. In a prospective longitudinal study of psychological changes in athletes following ACLR, Langford et al. (2008) demonstrated significant differences in ACL-RSI scores between athletes who had returned to full competition at 12 months, and those who had not. Athletes who failed to return to competitive sport scored lower on the ACL-RSI at both 6 months, prior to receiving medical RTS clearance, and at 12 months following ACLR. Lower scores represented a more negative psychological response to sport resumption. Thus, athletes' perception of RTS readiness was significantly related to whether or not they returned to full competition. Although surgeons may ask their patients subjectively if they feel confident to participate in sport, only 6.7% of surgeons and 5.2% of physiotherapists in this study used the ACL-RSI outcome measure in their clinical practice. Inclusion of a standardized outcome measure such as the ACL-RSI should be considered in the management of patients following ACLR to identify those athletes who may require psychological support and implement appropriate management strategies to assist them in returning to full competition.

With respect to patient care, this study's findings support the concept of further study into the potential role of physiotherapists making primary RTS decisions following ACLR. Considering the expertise of an orthopaedic physiotherapist, it seems reasonable to explore the feasibility of reallocating financial resources and the burden of care from surgeons as clinical decision makers post ACLR. Increasingly, there is a growing trend towards interprofessional health care models and delivery systems. Given the current climate of health care, it seems prudent to explore a variety of methods of allocation of resources to maximize health care dollars. Further study is necessary to ascertain an appropriate delivery model, level of professional training, proficiency in decision making skills, and agreement as to appropriate RTS criteria.

A trend towards increased use of HT graft was demonstrated in this study with HT being the dominant choice of graft at 79.5%. Limited use of BPTB graft may have been due to concern for donor site morbidity, especially in younger athletes involved in jumping or kneeling sports which place a high demand on the patellar tendon. This may represent the individualization of surgical management based on the patient profile and involvement in certain sports. A surgeon's familiarity and success with a particular technique, will likely impact their preference for choice of graft. Higher use of HT grafts may likewise represent a cross-cultural difference in surgical methods compared with previously reported graft choices. Data collected from large prospectively collected primary ACLR cohorts by the MOON consortium, a group of 7 academic medical centres in the United States, demonstrated similar usage of BPTB and HT grafts (Magnussen et al., 2010). HT grafts and BPTB grafts in that study accounted for 44% and 42% of primary ACLRs. Use of allograft was limited to 13%, with 0.6% representing other choices of graft. In a systematic review of outcomes following revision ACLR, Wright et al. (2012) reported on the use of original graft material used in the repair. Of the 86.1% who underwent an autograft, 48% consisted of BPTB and 40% consisted of HT grafts. Use of an allograft was reported in 5.5% of the patients studies. Reasons for graft choice in the current study were not explored.

The results of this study indicate that high quality evidence refuting the benefits of postoperative bracing has not impacted clinical practice. Despite a systematic review of Level-I and Level II studies demonstrating bracing following ACLR did not protect against postoperative injury, decrease pain, improve range of knee motion, or improve knee stability (Kruse et al., 2012), 42% of the orthopaedic surgeons in this study reported prescribing the use of postoperative bracing following ACLR. Actual rates of postoperative brace use may be even higher, given the non-response rate of 18% to the question. Available evidence suggests that postoperative bracing is neither beneficial nor necessary as evaluated by impairment based measures. Further study to assess the safe return to sport and its timing would strengthen the argument against bracing following ACR (Kruse et al., 2012). The high financial cost of functional bracing incurred by patients under the direction of their surgeon is not supported by recent evidence. Patients unfamiliar with the research are currently investing in an unnecessary expense with the assumption that they will derive a perceived benefit from the investment. Available evidence has yet to shape clinical practice in the use of bracing following ACLR.

It is well recognized that the time constraints of clinicians is a barrier to participating in research and perhaps contributed to the low response rate of the survey. Attempts were made to make each survey respondent friendly by ensuring that they were brief and easy to complete. Despite a minimal number of questions posed, and an indicator of survey progress, non-response rates were high for all groups.

Similar studies have used comparable methodology, soliciting participation through the use of professional email distribution lists (Lynch et al., 2013). Participant recruitment in the current study was limited to 3 months. It is plausible that a longer period of data collection would have been associated with an increased participation rate. Additionally, the broad distribution of emails sent to orthopaedic surgeons registered with the COA may have included surgeons who do not include ACLR in their practice. This potential lack of relevance to individual clinical practice, concern about exposing oneself to computer viruses, or constraints on timely internet access may have weighed heavily on participation.

It is unclear how many legitimate email invitations were received by the current sampling approach. Approximately 1200 surgeons and 10000 physiotherapists were in the sampling frame. Assuming 50% of clinicians contacted are involved in ACLR management, the sampling frame would be corrected to approximately 600 orthopaedic surgeons, and 5000 physiotherapists. If the invitation to participate in this study was received by all members of each email distribution list, the response rate would be estimated to be 7% for surgeons, and 2% for physiotherapists. Assuming 50% of the targeted population received the invitation to participate in the study, the response rate would be estimated to be 14% for surgeons, and 4% for physiotherapists. This is much lower than previously reported response rates of 15-77% by surgeons to internet surveys (Leece et al., 2004), and makes generalizability difficult.

4.4.1 Clinical Implications

Until such time as standardized clinical decision guidelines are developed and validated, clinicians are urged to closely examine the literature to choose the most appropriate and comprehensive measures in considering the strenuous demands imposed on athletes knees when making return to sport decisions. Clinicians should seek a solid understanding of the different purposes for which each measurement is designed. Clinical measures of impairment such as ROM and strength may be ideally suited to evaluate changes over time, but may poorly discriminate which patients are able to return to pre-injury levels of sport following ACLR. Outcome measures chosen need to reflect appropriate patient goals using a wide spectrum of constructs, so that rehabilitation protocols and outcome measures adequately target postoperative deficits. Given the evidence that the highest rates of re-injury following ACLR occur at 7 months post surgery (Laboute et al., 2010), caution is advised in strictly adhering to the standard chronological criterion of 6 months to receive medical clearance. Multiple measures which include tests of functional performance, emotional response to injury, and patient self-report measures may provide the most comprehensive evaluation of a patient's level of athletic readiness. Finally, clinicians are advised to set realistic expectations of postsurgical outcomes with their patients prior to ACLR.

4.4.2 Study Limitations

There are several limitations that need to be considered when interpreting the results of this study. One of the limitations of our study was the sample size of both surgeons and physiotherapists. Clinicians are often inundated with survey requests and this may have contributed to lower response numbers. It is unclear how many potential respondents in our target population actually received our requests due to the nature of our electronic sampling and unconfirmed distribution lists, therefore accurate calculation of response rates is not possible.

Furthermore, web-based clinician surveys have consistently been shown to demonstrate 10% lower response rates compared with paper administered surveys (Dykema et al., 2013; Leece et al., 2004; and Shih & Fan, 2008). Researchers should be aware of the limitations of web-based surveys in their design of future studies, and encouraged to consider a mixed-method sampling design to include a traditional mail/paper version of the survey unless the sampling method is prohibitive. Additionally, the inclusion of a small monetary incentive may improve overall response rates.

Although the survey was administered to members of the COA and CPA, professional membership did not ensure clinical involvement in ACL injury management. As such, clinicians practicing outside membership groups would not have received the survey via email, and targeted distribution lists may have overestimated the number of clinicians appropriate for sampling. Increasing the scope of distribution to include a broader sampling of sports medicine experts such as researchers, sport medicine physicians, and physiatrists may have improved response numbers. Future studies may consider targeting multiple sports medicine and physical therapy organizations through the use of survey generating websites, professional distribution lists, subscription to sport medicine journals, and multidisciplinary orthopaedic treatment centres.

4.4.3 What this study adds to the literature

A strength of this study is the identification of gaps in knowledge of evidence based practice amongst Canadian orthopaedic surgeons and physiotherapists. Additionally, this study examined how clinicians define successful RTS following ACLR. Furthermore, it explored the attitudes of clinicians towards physiotherapists adopting a primary role in return to sport decisions following ACLR.

4.5 Conclusion

This study established current clinical practices amongst orthopaedic surgeons and physiotherapists to identify the potential need for future research into the development of clinical practice guidelines in establishing RTS readiness following ACLR.

The difference in graft selection between surgeons may reflect the lack of clarity surrounding the best choice of graft for functional outcome following ACLR. Likewise, despite best evidence refuting the benefit of postoperative functional bracing, the use of bracing in the management of patients following ACLR remains controversial.

Similarities between clinicians were demonstrated over several categories. Both surgeons and physiotherapists reported similar use of multiple outcome measures emphasizing impairment measures, when making decisions about return to sport following ACLR. Additionally, both groups expressed support for the potential role of physiotherapists in making primary RTS decisions following ACLR, suggesting that the concept is worthy of further research.

Given the lack of understanding of the most appropriate measures for determining safe and successful return to pre-injury levels of sport, a consensus meeting of experts to evaluate the best evidence and provide direction for future research is warranted.

REFERENCES

1. Alentorn-Geli, E., Myer, G., Silvers, H., Samitier, G., Romero, D., Lázaro-Haro, C., and Cugat, R. (2009). Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. *Knee Surgery, Sports Traumatology, Arthroscopy,* 17(7),705-729
2. Ardern, C. L., Taylor, N. F., Feller, J. A., & Webster, K. E. (2012). Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *The American Journal of Sports Medicine, 40*(1), 41-48.
3. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to sport following anterior cruciate ligament reconstruction surgery: A systematic review and meta-analysis of the state of play. *British Journal of Sports Medicine, 45*(7), 596-606.
4. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery two-thirds of patients have not returned by 12 months after surgery. *The American Journal of Sports Medicine, 39*(3), 538-543.
5. Barber-Westin, S. D., & Noyes, F. R. (2011). Factors used to determine return to unrestricted sports activities after anterior cruciate ligament

reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 27*(12), 1697-1705.

6. Barber-Westin, S. D., & Noyes, F. R. (2013). Reducing the risk of a reinjury following ACL reconstruction: What factors should be used to allow unrestricted return to sports activities? *The ACL-deficient knee* (pp. 343-355) Springer.
7. Barber-Westin, S. D., & Noyes, F. R. (2011). Objective criteria for return to athletics after anterior cruciate ligament reconstruction and subsequent reinjury rates: A systematic review. *The Physician and Sportsmedicine, 39*(3), 100-110. doi: 10.3810/psm.2011.09.1926; 10.3810/psm.2011.09.1926
8. Birmingham, T.B., Kramer, J.F., Kirkley, A., Inglis, J.T., Spaulding, S.J., & Vandervoort, A.A. (2001). Knee bracing after ACL reconstruction: effects on postural control and proprioception. *Medicine and Science in Sports and Exercise*, 33(8), 1253-1258.
9. Briggs, K. K., Lysholm, J., Tegner, Y., Rodkey, W. G., Kocher, M. S., & Steadman, J. R. (2009). The reliability, validity, and responsiveness of the lysholm score and tegner activity scale for anterior cruciate ligament injuries of the knee 25 years later. *The American Journal of Sports Medicine, 37*(5), 890-897.

10. Dillman, D. A., Tortora, R. D., & Bowker, D. (1998, August). Principles for constructing web surveys. In *Joint Meetings of the American Statistical Association*.

11. Dillman, D.A., Smyth, J.D., & Christian, L.M. (2009). *Internet, mail, and mixed-mode surveys. The tailored design method* (3rd ed.) Hoboken: John Wiley & Sons.

12. Dugan, S. A. (2005). Sports-related knee injuries in female athletes: What gives? *American Journal of Physical Medicine & Rehabilitation, 84*(2), 122-130.

13. Eastlack, M.E., Axe, M.J., and Snyder-Mackler, L. (1999). Laxity, instability, and functional outcome after ACL injury: copers versus noncopers. *Medicine and Science in Sports and Exercise*, 31(2):210-215.

14. Feller, J., & Webster, K. E. (2013). Return to sport following anterior cruciate ligament reconstruction. *International Orthopaedics, 37*(2), 285-290.

15. Fitzgerald, G., Axe, M., & Snyder-Mackler, L. (2000). A decision-making scheme for returning patients to high-level activity with nonoperative treatment after anterior cruciate ligament rupture. *Knee Surgery, Sports Traumatology, Arthroscopy, 8*(2), 76-82.

16. Foster, T. E., Wolfe, B. L., Ryan, S., Silvestri, L., & Kaye, E. K. (2010). Does the graft source really matter in the outcome of patients undergoing anterior cruciate ligament reconstruction? An evaluation of autograft

versus allograft reconstruction results: a systematic review. *The American Journal of Sports Medicine*, *38*(1), 189-199.

17. Gilchrist, J., Mandelbaum, B. R., Melancon, H., Ryan, G. W., Silvers, H. J., Griffin, L. Y., . . . Dvorak, J. (2008). A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *The American Journal of Sports Medicine, 36*(8), 1476-1483.

18. Gissane, C., White, J., Kerr, K., & Jennings, D. (2001). An operational model to investigate contact sports injuries. *Medicine and Science in Sports and Exercise, 33*(12), 1999-2003.

19. Gobbi, A., & Francisco, R. (2006). Factors affecting return to sports after anterior cruciate ligament reconstruction with patellar tendon and hamstring graft: A prospective clinical investigation. *Knee Surgery, Sports Traumatology, Arthroscopy, 14*(10), 1021-1028.

20. Heijne, A., Axelsson, K., Werner, S., & Biguet, G. (2008). Rehabilitation and recovery after anterior cruciate ligament reconstruction: Patients' experiences. *Scandinavian Journal of Medicine & Science in Sports, 18*(3), 325-335.

21. Hewett, T. E., Di Stasi, S. L., & Myer, G. D. (2013). Current concepts for injury prevention in athletes after anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine, 41*(1), 216-224.

22. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.

23. Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Colosimo, A. J., McLean, S. G., . . . Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes A prospective study. *The American Journal of Sports Medicine, 33*(4), 492-501.

24. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.

25. Hewett, T. E., Myer, G. D., & Ford, K. R. (2006). Anterior cruciate ligament injuries in female athletes part 1, mechanisms and risk factors. *The American Journal of Sports Medicine, 34*(2), 299-311.

26. Holm, I., Øiestad, B. E., Risberg, M. A., & Aune, A. K. (2010). No Difference in Knee Function or Prevalence of Osteoarthritis After Reconstruction of the Anterior Cruciate Ligament With 4-Strand Hamstring Autograft Versus Patellar Tendon–Bone Autograft A Randomized Study With 10-Year Follow-up. *The American Journal of Sports Medicine*, *38*(3), 448-454.

27. Irrgang, J.J. (2008). Current status of measuring clinical outcomes after anterior cruciate ligament reconstruction: are we good enough? *Operative Techniques in Sports Medicine*, 16, 119-124.

28. Jette, D.U., Halbert, J., Iverson, C., Miceli, E., and Shah, P. (2009). Use of standardized outcome measures in physical therapist practice: perceptions and applications. *Physical Therapy*, 89(2), 125-135.

29. Kaplowitz, M.D., Lupi, R., Couper, M.P., and Thorp, L. (2012). The Effect of Invitation Design on Web Survey Response Rates. *Social Science Computer Review*, 30(3),339-349.

30. Kartus, J., Stener, S., Köhler, K., Sernert, N., Eriksson, B. I., & Karlsson, J. (1997). Is bracing after anterior cruciate ligament reconstruction necessary? A 2-year follow-up of 78 consecutive patients rehabilitated with or without a brace. *Knee Surgery, Sports Traumatology, Arthroscopy*, *5*(3), 157-161.

31. Kennedy, D.M., Robarts, S., & Woodhouse, L. (2010). Patients are satisfied with advanced practice physiotherapists in a role traditionally performed by orthopaedic surgeons. *Physiotherapy Canada*, 62(4), 298-305.

32. Keusch, F. (2012). How to Increase Response Rates in List-Based Web Survey Samples. *Social Science Computer Review*, 30(3):380-388.

33. Kvist, J., Ek, A., Sporrstedt, K., & Good, L. (2005). Fear of re-injury: A hindrance for returning to sports after anterior cruciate ligament

reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 13*(5), 393-397.

34. Laboute, E., Savalli, L., Puig, P., Trouve, P., Sabot, G., Monnier, G., & Dubroca, B. (2010). Analysis of return to competition and repeat rupture for 298 anterior cruciate ligament reconstructions with patellar or hamstring tendon autograft in sportspeople. *Annals of Physical and Rehabilitation Medicine*, 53, 598-614.
35. Langford, J. L., Webster, K. E., & Feller, J. A. (2009). A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine, 43*(5), 377-378.
36. Leece, P., Bhandari, M, Sprague, S., Swiontkowski, M.F., Schemitsch, M.H., Tornetta III,P.,…& Guyatt, H. (2004). Internet versus mailed questionnaires: a controlled comparison (2). Journal of medical Internet research 6(4).
37. Lentz, T. A., Tillman, S. M., Indelicato, P. A., Moser, M. W., George, S. Z., & Chmielewski, T. L. (2009). Factors associated with function after anterior cruciate ligament reconstruction. *Sports Health: A Multidisciplinary Approach, 1*(1), 47-53.
38. Lephart, S. M., Abt, J. P., & Ferris, C. M. (2002). Neuromuscular contributions to anterior cruciate ligament injuries in females. *Current Opinion in Rheumatology, 14*(2), 168-173.

39. Lephart, S. M., Perrin, D., Fu, F., Gieck, J., McCue, F., & Irrgang, J. (1992). Relationship between Selected Physical Characteristics and Functional Capacity in the Anterior Cruciate Ligament Insufficient Individual, *Journal of Orthopaedic and Sports Physical Therapy, 16(4), 174-181.*

40. Leung, W.C. (2001). How to Design a Questionnaire. *Student British Medical Journal*, 9:187-189.

41. Lewek, M.D., Chmielewski, T.L., Risberg, M.A., & Snyder-Mackler, L. (2003). Dynamic knee stability after anterior cruciater ligament rupture. *Exercise and sport sciences reviews*, 31(4), 195-200.

42. Lynch, A. D., Logerstedt, D. S., Grindem, H., Eitzen, I., Hicks, G. E., Axe, M. J., ... & Snyder-Mackler, L. (2013). Consensus criteria for defining 'successful outcome'after ACL injury and reconstruction: a Delaware-Oslo ACL cohort investigation. *British journal of sports medicine*.

43. Manal, T. J., & Snyder-Mackler, L. (1996). Practice guidelines for anterior cruciate ligament rehabilitation: A criterion-based rehabilitation progression. *Operative Techniques in Orthopaedics, 6*(3), 190-196.

44. Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y., . . . Garrett, W. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes 2-year follow-up. *The American Journal of Sports Medicine, 33*(7), 1003-1010.

45. Marx, R. G., Stump, T. J., Jones, E. C., Wickiewicz, T. L., & Warren, R. F. (2001). Development and evaluation of an activity rating scale for disorders of the knee. *The American Journal of Sports Medicine, 29*(2), 213-218.

46. Matsumoto, A., Yoshiya, S., Muratsu, H., Yagi, M., Iwasaki, Y., Kurosaka, M., & Kuroda, R. (2006). A comparison of bone–patellar tendon–bone and bone–hamstring tendon–bone autografts for anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine*, *34*(2), 213-219.

47. McDevitt, E.R., Taylor, D.C., Miller, M.D., Gerber, J.P., Ziemke, G., Hinkin, D., …& Pierre, P.S. (2004). Functional bracing after anterior cruciate ligament reconstruction: A prospective, randomized, multicentre study. *The American journal of sports medicine*, 32(8), 1887-1892.

48. Möller, E., Forssblad, M., Hansson, L., Wange, P., & Weidenhielm, L. (2001). Bracing versus nonbracing in rehabilitation after anterior cruciate ligament reconstruction: a randomized prospective study with 2-year follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *9*(2), 102-108.

49. Myklebust, G., & Bahr, R. (2005). Return to play guidelines after anterior cruciate ligament surgery. *British Journal of Sports Medicine, 39*(3), 127-131.

50. Reinhardt, K. R., Hetsroni, I., & Marx, R. G. (2010). Graft selection for anterior cruciate ligament reconstruction: a level I systematic review

comparing failure rates and functional outcomes. *Orthopedic Clinics of North America*, *41*(2), 249-262.

51. Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., . . . Krosshaug, T. (2008). Non-contact ACL injuries in female athletes: An international olympic committee current concepts statement. *British Journal of Sports Medicine, 42*(6), 394-412.
52. Risberg, M. A., Beynnon, B. D., Peura, G. D., & Uh, B. S. (1999). Proprioception after anterior cruciate ligament reconstruction with and without bracing. *Knee Surgery, Sports Traumatology, Arthroscopy*, *7*(5), 303-309.
53. Ross, M. D., Irrgang, J. J., Denegar, C. R., McCloy, C. M., & Unangst, E. T. (2002). The relationship between participation restrictions and selected clinical measures following anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 10*(1), 10-19.
54. Shaw, T., Chipchase, L. S., & Williams, M. T. (2004). A users guide to outcome measurement following ACL reconstruction. *Physical Therapy in Sport, 5*(2), 57-67.
55. Shi,T., and Fan. X. (2008). Comparing Response Rates from Web and Mail Surveys: A Meta-Analysis. *Field Methods*, 20(3), 249-271. doi: 10.1177/1525822X08317085
56. Shimokochi, Y., & Shultz, S. J. (2008). Mechanisms of noncontact anterior cruciate ligament injury. *Journal of Athletic Training, 43*(4), 396.

57. Smith, F., Rosenlund, E., Aune, A., MacLean, J., & Hillis, S. (2004). Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine, 38*(3), 279-284.

58. Snyder-Mackler, L., Fitzgerald, G.K., Bartolozzi, A.R., and Ciccotti, M.G. (1997). The relationship between passive joint laxity and functional outcome after anterior cruciate ligament injury. *American Journal of Sports Medicine*, 25(2), 191-195.

59. Spindler, K. P., Huston, L. J., Wright, R. W., Kaeding, C. C., Marx, R. G., Amendola, A., . . . Harrell, F. E. (2011). The prognosis and predictors of sports function and activity at minim*um 6 years after anterior cruciate liga*ment reconstruction A population cohort study. *The American Journal of Sports Medicine, 39*(2), 348-359.

60. Tegner, Y., & Lysholm, J. (1985). Rating systems in the evaluation of knee ligament injuries. *Clinical Orthopaedics and Related Research, 198*, 42-49.

61. Vicente, P., and Reis, E. (201*0). Using Questionniare Design to Fight Non*response Bias in Web Surveys. *Social Science Computer Review*, 28(2):251-267.

62. Webster, K. E., Feller, J. A., & Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Physical Therapy in Sport, 9*(1), 9-15.

63. Williams, G. N., Taylor, D. C., Gangel, T. J., Uhorchak, J. M., & Arciero, R. A. (2000). Comparison of the single assessment numeric evaluation method and the lysholm score. *Clinical Orthopaedics and Related Research, 373*, 184-192.

64. Wright, R.W., & Fetzer, G.B. (2007). Bracing after ACL reconstruction: a systematic review. *Clinical orthopaedics and related research*, 455, 162-168.

65. Wright, R. W., Gill, C. S., Chen, L., Brophy, R. H., Matava, M. J., Smith, M. V., & Mall, N. A. (2012). Outcome of revision anterior cruciate ligament reconstruction: a systematic review. *The Journal of Bone & Joint Surgery*, *94*(6), 531-536.

66. Wu, G. K., Ng, G. Y., & Mak, A. F. (2001). Effects of knee bracing on the sensorimotor function of subjects with anterior cruciate ligament reconstruction. *The American journal of sports medicine*, *29*(5), 641-645.

67. Zebis, M. K., Andersen, L. L., Bencke, J., Kjær, M., & Aagaard, P. (2009). Identification of athletes at future risk of anterior cruciate ligament ruptures by neuromuscular screening. *The American Journal of Sports Medicine, 37*(10), 1967-1973.

CHAPTER 5

RTS FOLLOWING ACLR: DISCUSSION AND CONCLUSION

Despite ACLR being the standard of care for athletes wishing to return to their pre-injury level of sport following ACL rupture, significant problems remain. Consensus on a gold standard outcome measure of patient readiness for resuming athletic participation does not exist. Lower levels of athletic activity and quality of life scores, along with higher levels of pain frequently experienced by patients undergoing revision ACLR (Wright et al., 2011) make a strong case for determining which outcome measures best predict an athlete's safe RTS readiness, in order to prevent a repeat ACL injury. Additionally, establishing consensus based criteria for realistic success following ACLR would help manage patient expectations with respect to RTS, and lay a foundation for the future development of clinical practice guidelines.

The overall objective of this thesis was to examine clinician based decision making processes surrounding RTS following ACLR to identify any gaps in knowledge which need to be addressed prior to any future development of clinical practice guidelines for returning an athlete to athletic participation. Problematically, the definition of successful RTS following ACLR from the perspective of both the clinician and the patient has not been well identified. This is especially important, given that discrepancies frequently exist between medical clearance to resume athletic participation and patients' self reported perception of preparedness. Mutually agreed upon definitions of success need to be established to ensure appropriate patient expectations and level of satisfaction. This is only possible if clinicians and patients are working under clearly defined measures of successful outcome. In the first study, patients frequently reported giving way, as a reason for choosing surgical management. Furthermore, functional stability was cited by patient respondents as one of two unanimously agreed upon measures of success following ACLR. However, subjective patient reports of giving way presented the greatest discrepancy between clinicians who felt the outcome measure contributed to their clinical decision making. Sixty-nine percent of surgeons based their decision making on patient reports of giving way compared with only 8.5% of physiotherapists. Neither group met the operational definition for consensus employed by Lynch et al. (2013) in defining criteria for successful RTS. This suggests that the current practice of clinical RTS decision making is not derived from patient defined measures of success. Patient directed goals and the unique physical demands of each sport necessitate an individual approach to progressive reintegration into physical activity within the framework of the ICF. It is arguable that the collaboration of both clinicians and patients in the goal setting and decision making process will result in more meaningful, timely, safe, and individually appropriate RTS outcomes.

Return to pre-injury level of sport is often cited as the gold standard measure of success when evaluating clinical protocols. However, studies often do not differentiate between levels of sports participation when reporting RTS rates. While all groups questioned agreed with RTS as a valid measure of success, athletes and physiotherapists more frequently reported a higher expectation of returning to a pre-injury level of sport following ACLR than did surgeons. The disconnect between patients' perceived measure of success and the attainment of RTS at a lower level of participation appeared to be associated with a lower level of patient satisfaction. It is recommended that future research define standard terminology for RTS, encompassing multiple participatory levels across which studies can be compared for successful RTS rates. Knowledge of RTS rates at varying levels of sports participation will then enable patients to set realistic expectations of outcomes following ACLR.

Within the context of health care, a fundamental assumption is that patient satisfaction is dependent on the fulfillment of preformed expectations. However, the contribution of expectations as a causal factor in the determination of patient satisfaction following ACLR has yet to be elucidated. A clearer understanding of surgical limitations and a surgeon's expectation of success may help inform a patient's decision between surgical or conservative management, and directly impact their level of satisfaction post treatment. Further study is warranted to prospectively assess the contribution of patient expectations on their level of satisfaction with outcomes at all levels of the ICF following ACLR. It represents a new and interesting opportunity to explore in future research.

Measures of health care outcomes frequently encompass generic measures of quality of health, condition-specific measures, and levels of patient satisfaction. When compared with recent consensus derived criteria for RTS decision making, surgeon response demonstrated gaps in clinical practice. Clinicians in this study reported a heavy bias toward measures of impairment and function, despite the existence of well validated outcome measures at the level of participation. The minimal utilization of validated patient reported and activity level outcome measures by both surgeons and physiotherapists is concerning, as it represents a disconnect between the state of current evidence, patient directed goals, and clinical practice patterns.

Historically, RTS paradigms have been based on temporal timelines, with athletes most commonly receiving RTS clearance at 6 months (Ardern et al., 2011; Barber-Westin and Noyes, 2011). Similar timelines were reported by orthopaedic surgeons in this study. Reconsideration of medical clearance timelines to reflect attainment of functional and performance based criteria is warranted, given poorer than expected RTS outcomes, high levels of re-injury rates, and evidence of persistent neuromuscular and biomechanical deficits months and sometimes years following ACLR (Hewett et al., 2013). Increased consideration should be given to an evidence based approach focusing on modifiable neuromuscular and biomechanical risk factors to mitigate the risk of subsequent re-injury and the development of early or more advanced osteoarthritis. This is in keeping with Myklebust and Bahr (2005), who approached RTS decisions from a more philosophical perspective, suggesting that perhaps the definition of successful outcome following ACLR needs to shift away from returning athletes to sport towards a measure of long term knee health. Returning to high level pivoting and cutting sports may not be possible for all athletes, and decisions surrounding retirement from sport need to be further explored.

In conclusion, there is currently a lack of evidence to guide clinical practice in determining which battery of outcome measures best determine whether a patient is able to successfully return to sport following ACLR. Validating an operational definition of success is an important next step in the development of goal oriented RTS clinical practice guidelines. Prospective study is needed to assess the ability of consensus derived outcome measures to predict athlete readiness. Ultimately, the dissemination of this knowledge at all levels of professional training is necessary to establish best practice medicine. This has implications on the establishment of post-secondary program content development and delivery, in addition to facilitating knowledge translation to practicing clinicians.

REFERENCES

1. Alentorn-Geli, E., Myer, G., Silvers, H., Samitier, G., Romero, D., Lázaro-Haro, C., and Cugat, R. (2009). Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. *Knee Surgery, Sports Traumatology, Arthroscopy,* 17(7),705-729
2. Ardern, C. L., Taylor, N. F., Feller, J. A., & Webster, K. E. (2012). Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *The American Journal of Sports Medicine, 40*(1), 41-48.
3. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to sport following anterior cruciate ligament reconstruction surgery: A systematic review and meta-analysis of the state of play. *British Journal of Sports Medicine, 45*(7), 596-606.
4. Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery two-thirds of patients have not returned by 12 months after surgery. *The American Journal of Sports Medicine, 39*(3), 538-543.
5. Barber-Westin, S. D., & Noyes, F. R. (2011). Factors used to determine return to unrestricted sports activities after anterior cruciate ligament

reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 27*(12), 1697-1705.

6. Barber-Westin, S. D., & Noyes, F. R. (2013). Reducing the risk of a reinjury following ACL reconstruction: What factors should be used to allow unrestricted return to sports activities? *The ACL-deficient knee* (pp. 343-355) Springer.
7. Barber-Westin, S. D., & Noyes, F. R. (2011). Objective criteria for return to athletics after anterior cruciate ligament reconstruction and subsequent reinjury rates: A systematic review. *The Physician and Sportsmedicine, 39*(3), 100-110. doi: 10.3810/psm.2011.09.1926; 10.3810/psm.2011.09.1926
8. Birmingham, T.B., Kramer, J.F., Kirkley, A., Inglis, J.T., Spaulding, S.J., & Vandervoort, A.A. (2001). Knee bracing after ACL reconstruction: effects on postural control and proprioception. *Medicine and Science in Sports and Exercise*, 33(8), 1253-1258.
9. Briggs, K. K., Lysholm, J., Tegner, Y., Rodkey, W. G., Kocher, M. S., & Steadman, J. R. (2009). The reliability, validity, and responsiveness of the lysholm score and tegner activity scale for anterior cruciate ligament injuries of the knee 25 years later. *The American Journal of Sports Medicine, 37*(5), 890-897.

10. Dillman, D.A., Smyth, J.D., & Christian, L.M. (2009). *Internet, mail, and mixed-mode surveys. The tailored design method* (3rd ed.) Hoboken: John Wiley & Sons.

11. Dugan, S. A. (2005). Sports-related knee injuries in female athletes: What gives? *American Journal of Physical Medicine & Rehabilitation, 84*(2), 122-130.

12. Eastlack, M.E., Axe, M.J., and Snyder-Mackler, L. (1999). Laxity, instability, and functional outcome after ACL injury: copers versus noncopers. *Medicine and Science in Sports and Exercise*, 31(2):210-215.

13. Feller, J., & Webster, K. E. (2013). Return to sport following anterior cruciate ligament reconstruction. *International Orthopaedics, 37*(2), 285-290.

14. Fitzgerald, G., Axe, M., & Snyder-Mackler, L. (2000). A decision-making scheme for returning patients to high-level activity with nonoperative treatment after anterior cruciate ligament rupture. *Knee Surgery, Sports Traumatology, Arthroscopy, 8*(2), 76-82.

15. Gilchrist, J., Mandelbaum, B. R., Melancon, H., Ryan, G. W., Silvers, H. J., Griffin, L. Y., . . . Dvorak, J. (2008). A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *The American Journal of Sports Medicine, 36*(8), 1476-1483.

16. Gissane, C., White, J., Kerr, K., & Jennings, D. (2001). An operational model to investigate contact sports injuries. *Medicine and Science in Sports and Exercise, 33*(12), 1999-2003.

17. Gobbi, A., & Francisco, R. (2006). Factors affecting return to sports after anterior cruciate ligament reconstruction with patellar tendon and hamstring graft: A prospective clinical investigation. *Knee Surgery, Sports Traumatology, Arthroscopy, 14*(10), 1021-1028.

18. Heijne, A., Axelsson, K., Werner, S., & Biguet, G. (2008). Rehabilitation and recovery after anterior cruciate ligament reconstruction: Patients' experiences. *Scandinavian Journal of Medicine & Science in Sports, 18*(3), 325-335.

19. Hewett, T. E., Di Stasi, S. L., & Myer, G. D. (2013). Current concepts for injury prevention in athletes after anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine, 41*(1), 216-224.

20. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.

21. Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Colosimo, A. J., McLean, S. G., . . . Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior

cruciate ligament injury risk in female athletes A prospective study. *The American Journal of Sports Medicine, 33*(4), 492-501.

22. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes part 2, A meta-analysis of neuromuscular interventions aimed at injury prevention. *The American Journal of Sports Medicine, 34*(3), 490-498.
23. Hewett, T. E., Myer, G. D., & Ford, K. R. (2006). Anterior cruciate ligament injuries in female athletes part 1, mechanisms and risk factors. *The American Journal of Sports Medicine, 34*(2), 299-311.
24. Irrgang, J.J. (2008). Current status of measuring clinical outcomes after anterior cruciate ligament reconstruction: are we good enough? *Operative Techniques in Sports Medicine*, 16, 119-124.
25. Jette, D.U., Halbert, J., Iverson, C., Miceli, E., and Shah, P. (2009). Use of standardized outcome measures in physical therapist practice: perceptions and applications. *Physical Therapy*, 89(2), 125-135.
26. Kaplowitz, M.D., Lupi, R., Couper, M.P., and Thorp, L. (2012). The Effect of Invitation Design on Web Survey Response Rates. *Social Science Computer Review*, 30(3),339-349.
27. Kartus, J., Stener, S., Köhler, K., Sernert, N., Eriksson, B. I., & Karlsson, J. (1997). Is bracing after anterior cruciate ligament reconstruction necessary? A 2-year follow-up of 78 consecutive patients rehabilitated with

or without a brace. *Knee Surgery, Sports Traumatology, Arthroscopy*, *5*(3), 157-161.

28. Kennedy, D.M., Robarts, S., & Woodhouse, L. (2010). Patients are satisfied with advanced practice physiotherapists in a role traditionally performed by orthopaedic surgeons. *Physiotherapy Canada*, 62(4), 298-305.
29. Keusch, F. (2012). How to Increase Response Rates in List-Based Web Survey Samples. *Social Science Computer Review*, 30(3):380-388.
30. Kvist, J., Ek, A., Sporrstedt, K., & Good, L. (2005). Fear of re-injury: A hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 13*(5), 393-397.
31. Laboute, E., Savalli, L., Puig, P., Trouve, P., Sabot, G., Monnier, G., & Dubroca, B. (2010). Analysis of return to competition and repeat rupture for 298 anterior cruciate ligament reconstructions with patellar or hamstring tendon autograft in sportspeople. *Annals of Physical and Rehabilitation Medicine*, 53, 598-614.
32. Langford, J. L., Webster, K. E., & Feller, J. A. (2009). A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine, 43*(5), 377-378.

33. Leece, P., Bhandari, M, Sprague, S., Swiontkowski, M.F., Schemitsch, M.H., Tornetta III,P.,…& Guyatt, H. (2004). Internet versus mailed questionnaires: a controlled comparison (2). Journal of medical Internet research 6(4).
34. Lentz, T. A., Tillman, S. M., Indelicato, P. A., Moser, M. W., George, S. Z., & Chmielewski, T. L. (2009). Factors associated with function after anterior cruciate ligament reconstruction. *Sports Health: A Multidisciplinary Approach, 1*(1), 47-53.
35. Lephart, S. M., Abt, J. P., & Ferris, C. M. (2002). Neuromuscular contributions to anterior cruciate ligament injuries in females. *Current Opinion in Rheumatology, 14*(2), 168-173.
36. Lephart, S. M., Perrin, D., Fu, F., Gieck, J., McCue, F., & Irrgang, J. (1992). Relationship between Selected Physical Characteristics and Functional Capacity in the Anterior Cruciate Ligament Insufficient Individual, *Journal of Orthopaedic and Sports Physical Therapy, 16(4), 174-181.*
37. Leung, W.C. (2001). How to Design a Questionnaire. *Student British Medical Journal*, 9:187-189.
38. Lewek, M.D., Chmielewski, T.L., Risberg, M.A., & Snyder-Mackler, L. (2003). Dynamic knee stability after anterior cruciater ligament rupture. *Exercise and sport sciences reviews*, 31(4), 195-200.

39. Manal, T. J., & Snyder-Mackler, L. (1996). Practice guidelines for anterior cruciate ligament rehabilitation: A criterion-based rehabilitation progression. *Operative Techniques in Orthopaedics, 6*(3), 190-196.

40. Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y., . . . Garrett, W. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes 2-year follow-up. *The American Journal of Sports Medicine, 33*(7), 1003-1010.

41. Marx, R. G., Stump, T. J., Jones, E. C., Wickiewicz, T. L., & Warren, R. F. (2001). Development and evaluation of an activity rating scale for disorders of the knee. *The American Journal of Sports Medicine, 29*(2), 213-218.

42. McDevitt, E.R., Taylor, D.C., Miller, M.D., Gerber, J.P., Ziemke, G., Hinkin, D., …& Pierre, P.S. (2004). Functional bracing after anterior cruciate ligament reconstruction: A prospective, randomized, multicentre study. *The American journal of sports medicine*, 32(8), 1887-1892.

43. Möller, E., Forssblad, M., Hansson, L., Wange, P., & Weidenhielm, L. (2001). Bracing versus nonbracing in rehabilitation after anterior cruciate ligament reconstruction: a randomized prospective study with 2-year follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *9*(2), 102-108.

44. Myklebust, G., & Bahr, R. (2005). Return to play guidelines after anterior cruciate ligament surgery. *British Journal of Sports Medicine, 39*(3), 127-131.

45. Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., . . . Krosshaug, T. (2008). Non-contact ACL injuries in female athletes: An international olympic committee current concepts statement. *British Journal of Sports Medicine, 42*(6), 394-412.

46. Risberg, M. A., Beynnon, B. D., Peura, G. D., & Uh, B. S. (1999). Proprioception after anterior cruciate ligament reconstruction with and without bracing. *Knee Surgery, Sports Traumatology, Arthroscopy*, *7*(5), 303-309.

47. Ross, M. D., Irrgang, J. J., Denegar, C. R., McCloy, C. M., & Unangst, E. T. (2002). The relationship between participation restrictions and selected clinical measures following anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy, 10*(1), 10-19.

48. Shaw, T., Chipchase, L. S., & Williams, M. T. (2004). A users guide to outcome measurement following ACL reconstruction. *Physical Therapy in Sport, 5*(2), 57-67.

49. Shi,T., and Fan. X. (2008). Comparing Response Rates from Web and Mail Surveys: A Meta-Analysis. *Field Methods*, 20(3), 249-271. doi: 10.1177/1525822X08317085

50. Shimokochi, Y., & Shultz, S. J. (2008). Mechanisms of noncontact anterior cruciate ligament injury. *Journal of Athletic Training, 43*(4), 396.

51. Smith, F., Rosenlund, E., Aune, A., MacLean, J., & Hillis, S. (2004). Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine, 38*(3), 279-284.

52. Snyder-Mackler, L., Fitzgerald, G.K., Bartolozzi, A.R., and Ciccotti, M.G. (1997). The relationship between passive joint laxity and functional outcome after anterior cruciate ligament injury. *American Journal of Sports Medicine*, 25(2), 191-195.

53. Spindler, K. P., Huston, L. J., Wright, R. W., Kaeding, C. C., Marx, R. G., Amendola, A., . . . Harrell, F. E. (2011). The prognosis and predictors of sports function and activity at minim*um 6 years after anterior cruciate liga*ment reconstruction A population cohort study. *The American Journal of Sports Medicine, 39*(2), 348-359.

54. Tegner, Y., & Lysholm, J. (1985). Rating systems in the evaluation of knee ligament injuries. *Clinical Orthopaedics and Related Research, 198*, 42-49.

55. Vicente, P., and Reis, E. (201*0). Using Questionniare Design to Fight Non*response Bias in Web Surveys. *Social Science Computer Review*, 28(2):251-267.

56. Webster, K. E., Feller, J. A., & Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of

returning to sport following anterior cruciate ligament reconstruction surgery. *Physical Therapy in Sport, 9*(1), 9-15.

57. Williams, G. N., Taylor, D. C., Gangel, T. J., Uhorchak, J. M., & Arciero, R. A. (2000). Comparison of the single assessment numeric evaluation method and the lysholm score. *Clinical Orthopaedics and Related Research, 373*, 184-192.

58. Wright, R.W., & Fetzer, G.B. (2007). Bracing after ACL reconstruction: a systematic review. *Clinical orthopaedics and related research*, 455, 162-168.

59. Wu, G. K., Ng, G. Y., & Mak, A. F. (2001). Effects of knee bracing on the sensorimotor function of subjects with anterior cruciate ligament reconstruction. *The American journal of sports medicine*, *29*(5), 641-645.

60. Zebis, M. K., Andersen, L. L., Bencke, J., Kjær, M., & Aagaard, P. (2009). Identification of athletes at future risk of anterior cruciate ligament ruptures by neuromuscular screening. *The American Journal of Sports Medicine, 37*(10), 1967-1973.

APPENDICES

Appendix A.

ACL-Return to Sport After Injury Scale

Emotions

1. Are you nervous about playing your sport?
2. Do you find it frustrating to have to consider your knee with respect to your sport?
3. Do you feel relaxed about playing your sport?
4. Are you fearful of re-injuring your knee by playing your sport?
5. Are you afraid of accidentally injuring your knee by playing your sport?

Confidence in performance

6. Are you confident that your knee will not give way by playing your sport?
7. Are you confident that you could play your sport without concern for your knee?
8. Are your confident about your knee holding up under pressure?
9. Are you confident that you can perform at your previous level of sport participation?

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

Risk appraisal

11. Do you think you are likely to re-injure your knee by participating in your sport?
12. Do thoughts of having to go through surgery and rehabilitation again prevent you from playing your sport?

Appendix B.

Marx Activity Scale

Please indicate how often you performed each activity in your healthiest and most active state, in the year **PRIOR** to injuring your ACL.

	Less than one time in a month	**One time in a month**	**One time in a week**	**2 or 3 times in a week**	**4 or more times in a week**
Running: running while playing a sport or jogging					
Cutting: changing directions while running					
Decelerating: coming to a quick stop while running					
Pivoting: turning your body with your foot planted while playing a sport; for example: skiing, skating, kicking, throwing, hitting a ball (golf, tennis, squash), etc.					

Appendix C.

Tegner Activity Scale

Please indicate in the spaces below the **HIGHEST** level of activity that you participated in **BEFORE YOUR INJURY**, and the highest level you are able to participate in **CURRENTLY.**

Before injury: Level ________
Current activity: Level: ________

Level 10	Competitive sports- soccer, football, rugby (national elite)
Level 9	Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball
Level 8	Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing
Level 7	Competitive sports- tennis, running, motorcars speedway, handball Recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running
Level 6	Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week
Level 5	Work- heavy labor (construction, etc.) Competitive sports- cycling, cross-country skiing, Recreational sports- jogging on uneven ground at least twice weekly
Level 4	Work- moderately heavy labor (e.g. truck driving, etc.)
Level 3	Work- light labor (nursing, etc.)
Level 2	Work- light labor Walking on uneven ground possible, but impossible to back pack or hike
Level 1	Work- sedentary (secretarial, etc.)
Level 0	Sick leave or disability pension because of knee problems

Appendix D.

Single Assessment Numeric Evaluation

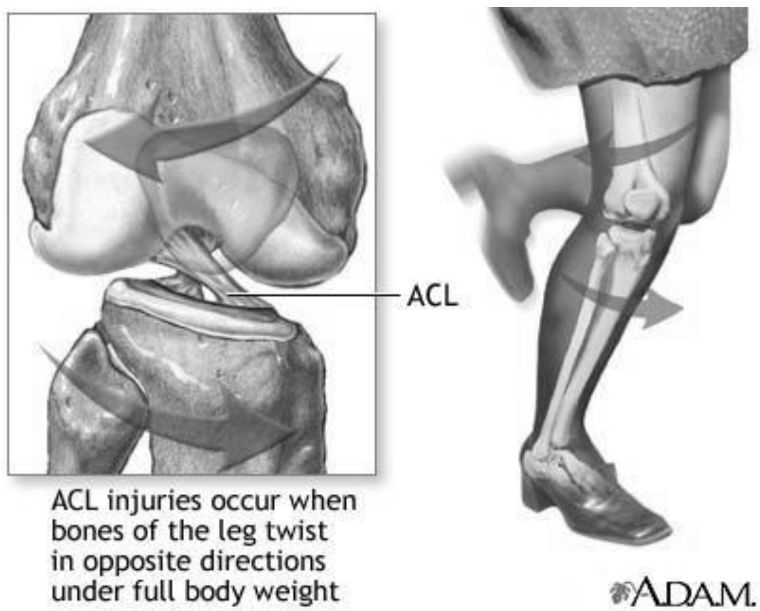
How satisfied are you with your current level of activity?

Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely

Appendix E.

Patient Web Survey Advertisement

Had your ACL reconstructed?



We want to know about your experiences about rehabilitation, and getting back in the game.

Please visit **http://fluidsurveys.com/s/returntosport/** to participate in a short web survey. Participation involves answering 19 on-line questions about your activity level, your experience surrounding the process of rehabilitation after ACL reconstruction, and your decisions surrounding returning to sport. The questionnaire will take 5-10 minutes to complete, is completely anonymous, and will have no influence on your medical care.

Jacquie Minnes PT
School of Rehabilitation Science
McMaster University
Inspiring Innovation and Discovery

Appendix F.

McMaster University

Inspiring Innovation and Discovery

Return to Play Decisions following ACL Reconstruction: McMaster Research Project

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Questionnaire Consent Form

Title

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines.

Investigators

Jacquie van Ierssel, PT, Dr. Joy MacDermid, PT, PhD., Dr. Lucas Murnaghan, MD

Background

Anterior cruciate ligament (ACL) injuries are one of the most common orthopaedic sports injuries, and significant burden on the athlete in terms of pain, disability, loss of sporting and social activity, and a financial burden due to medical costs and potential loss of income. ACL reconstruction is widely perceived as the only viable way to restore stability and functional biomechanics of the knee, thus allowing the athlete to successfully return to playing their sport. Despite the majority of athletes achieving good functional outcomes as measured by impairment and disability scales, only two thirds of them return to pre-injury level of sporting activity. There are currently no accepted standardized guidelines to evaluate successful return to sport following ACL reconstruction. Measures of impairment, disability and health status may exhibit a ceiling effect in competitive athletes, by failing to measure the more extreme physical and mental demands and athlete places on their knee during sporting activities. A more comprehensive understanding of the factors responsible for determining successful return to pre-injury sport levels is critical in developing evidence-based guidelines to assist clinicians in their return to play decisions.

Purpose

The purposes of this study are to (1) establish a baseline of current attitudes and practice amongst surgeons and physiotherapists in Canada in making return to play decisions following ACL reconstruction, (2) determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and (3) to gain a better understanding of how athletes and clinicians define successful return to sport and if any discrepancies in expectations exist between these groups.

What Do I have to Do?

Participation involves answering 19 questions via web survey about your activity level, your experience surrounding the process of rehabilitation after ACL reconstruction, and your decisions surrounding returning to sport. The questionnaire will take 3-5 minutes to complete.

What are the Risks?

There are no risks to participating. All individual responses will be kept confidential and only group statistics will be compiled and reported. Your participation will in no way influence your medical care.

What are the Benefits?

As a participant, there are no direct benefits to you. Your participation may help inform the future development of Clinical Practice Guidelines in establishing return to play readiness in athletes following ACLR.

Do I have to Participate?

No. Your participation is completely voluntary, and you may withdraw at anytime.

Confidentiality

All individual responses will be gathered anonymously and only group statistics will be compiled and reported.

Consent

Your participation in this survey indicates that you have understood to your satisfaction the information regarding your participation in this research project and agree to participate as a subject.

Hamilton Integrated Research Ethics Board has approved this research study.

Appendix G.

McMaster University

Inspiring Innovation and Discovery

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

Patients

I have read the survey information form and consent to participate.

☐ **I consent** ☐ **I do not consent**

Please answer the following questions:

1. What is your year of birth?

2. Gender M F

3. How many months ago was your initial injury

   6 7 8 9 10 11 12 13 14 15 16 17 18

4. How many months ago was your surgery?

   6 7 8 9 10 11 12 13 14 15 16 17 18

5. What type of graft was used?

   Left Right

   i. Patellar tendon
   ii. Semitendinosis
   iii. Allograft

6. Please check any concomitant surgical procedures for your current injury.

	Left	Right
i. Medial meniscotomy		
ii. Lateral meniscotomy		
iii. Chondroplasty		

7. How many previous ACL reconstructions have you had?

    i. L eft 0 1 2 3
    ii. Right 0 1 2 3

8. What was your deciding factor in choosing ACL reconstruction versus conservative management? Choose all that apply:

    i. Pain
    ii. Instabililty
    iii. Weakness
    iv. Problem with knee function
    v. Desire to return to pre-injury level of sport

9. At how many months post surgery were you medically cleared to return to sport?

    6 7 8 9 10 11 12 13 14 15 16 17 18 not yet cleared

10. At how many months post surgery did you feel ready to return to sport?

    6 7 8 9 10 11 12 13 14 15 16 17 18 not yet

11. On a scale from zero to 100, how would you rate your knee today (100 being normal)?

12. Please indicate how often you performed each activity in your healthiest and most active state, in the year **PRIOR** to injuring your ACL.

	Less than one time in a month	**One time in a month**	**One time in a week**	**2 or 3 times in a week**	**4 or more times in a week**
Running: running while playing a sport or jogging					
Cutting: changing directions while running					
Decelerating: coming to a quick stop while running					
Pivoting: turning your body with your foot planted while playing a sport; for example: skiing, skating, kicking, throwing, hitting a ball (golf, tennis, squash), etc.					

13. Please indicate how often you performed each activity in your healthiest and most active state, **SINCE** your ACL reconstruction.

	Less than one time in a month	**One time in a month**	**One time in a week**	**2 or 3 times in a week**	**4 or more times in a week**
Running: running while playing a sport or jogging					
Cutting: changing directions while running					
Decelerating: coming to a quick stop while running					
Pivoting: turning your body with your foot planted while playing a sport; for example: skiing, skating, kicking, throwing, hitting a ball (golf, tennis, squash), etc.					

14. Please indicate in the spaces below the **HIGHEST** level of activity that you participated in **<u>BEFORE YOUR INJURY</u>**, your **<u>EXPECTED LEVEL AFTER SURGERY</u>**, and the highest level you are able to participate in **<u>CURRENTLY</u>.**

Before injury: Level ________
Expected activity after surgery: Level ________
Current activity: Level: ________

Level 10	Competitive sports- soccer, football, rugby (national elite)
Level 9	Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball
Level 8	Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing
Level 7	Competitive sports- tennis, running, motorcars speedway, handball Recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running
Level 6	Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week
Level 5	Work- heavy labor (construction, etc.) Competitive sports- cycling, cross-country skiing, Recreational sports- jogging on uneven ground at least twice weekly
Level 4	Work- moderately heavy labor (e.g. truck driving, etc.)
Level 3	Work- light labor (nursing, etc.)
Level 2	Work- light labor Walking on uneven ground possible, but impossible to back pack or hike
Level 1	Work- sedentary (secretarial, etc.)
Level 0	Sick leave or disability pension because of knee problems

15. How satisfied are you with your current level of activity.

Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely

16. If you have returned to your pre-injury level of activity, please skip to question #18, IF NOT, please proceed with question #17.

17. Why have you not returned to your pre-injury level of activity? Please choose all that apply.

    a. Swelling
    b. Pain
    c. Lack of full range of movement
    d. Muscle weakness
    e. Knee instability
    f. Fear of re-injury or lack of confidence
    g. No motivation to continue
    h. Social reasons
    i. Lack of time
    j. Other

18. Rate the following questions on a scale of 0-10, with 0 being extremely and 10 not at all.

Question	Likert Scale 0-10	Importance of question	Satisfaction with current level
Are you nervous about playing your sport?			
Do you find it frustrating to have to consider your knee with respect to your sport?			
Do you feel relaxed about playing your sport?			
Are you fearful of re-injuring your knee by playing your sport?			
Are you afraid of accidentally injuring your knee by playing sport?			
Are you confident that your knee will not give way by playing sport?			
Are you confident that you could play your sport without concern for your knee?			
Are you confident about your knee holding up under pressure?			
Are you confident that you can perform at your previous level of sport participation?			

Are you confident about your ability to perform well at your sport?			
Do you think you are likely to re-injure your knee by participating in your sport?			
Do thoughts of having to go through surgery and rehabilitation again prevent you from playing your sport?			

19. What measures do you feel describe successful RTP.

Statement	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
Functional stability							
Pain free with daily activities, unable to participate in sport							
Able to participate in a reduced level of sport							
Able to participate in pre-injury level of sport with functional limitations							
Able to participate in pre-injury level of sport with decreased performance							
Able to fully participate in pre-injury level of sport with no limitations or deficits							
Able to participate in any level of sport without pain							
Able to participate in any level of sport with pain							

Thank you for participating in this survey.

Appendix H.

McMaster University

Inspiring Innovation and Discovery

Return to Play Decisions following ACL Reconstruction: McMaster Research Project

Questionnaire Consent Form

Title

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines.

Investigators

Jacquie van Ierssel, PT, Dr. Joy MacDermid, PT, PhD., Dr. Lucas Murnaghan, MD

Background

Anterior cruciate ligament (ACL) injuries are one of the most common orthopaedic sports injuries, and significant burden on the athlete in terms of pain, disability, loss of sporting and social activity, and a financial burden due to medical costs and potential loss of income. ACL reconstruction is widely perceived as the only viable way to restore stability and functional biomechanics of the knee, thus allowing the athlete to successfully return to playing their sport. Despite the majority of athletes achieving good functional outcomes as measured by impairment and disability scales, only two thirds of them return to pre-injury level of sporting activity. There are currently no accepted standardized guidelines to evaluate successful return to sport following ACL reconstruction.

Measures of impairment, disability and health status may exhibit a ceiling effect in competitive athletes, by failing to measure the more extreme physical and mental demands and athlete places on their knee during sporting activities. A more comprehensive understanding of the factors responsible for determining successful return to pre-injury sport levels is critical in developing evidence-based guidelines to assist clinicians in their return to play decisions.

Purpose

The purposes of this study are to (1) establish a baseline of current attitudes and practice amongst surgeons and physiotherapists in Canada in making return to play decisions following ACL reconstruction, (2) determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and (3) to gain a better understanding of how athletes and clinicians define successful return to sport and if any discrepancies in expectations exist between these groups.

What Do I have to Do?

Participation involves answering 10 closed format questions that include sections on demographics, outcome measures, treatment procedures, and return to sport decisions. The questionnaire should take 3-5 minutes to complete.

What are the Risks?

There are no risks to participating. All individual responses will be kept confidential and only group statistics will be compiled and reported. Your participation will in no way influence your medical care.

What are the Benefits?

As a participant, there are no direct benefits to you. Your participation may help inform the future development of Clinical Practice Guidelines in establishing return to play readiness in athletes following ACLR.

Do I have to Participate?

No. Your participation is completely voluntary, and you may withdraw at anytime.

Confidentiality

All individual responses will be gathered anonymously and only group statistics will be compiled and reported.

Consent

Your participation in this survey indicates that you have understood to your satisfaction the information regarding your participation in this research project and agree to participate as a subject.

Hamilton Integrated Research Ethics Board has approved this research study.

Appendix I.

McMaster University

Inspiring Innovation and Discovery

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

http://fluidsurveys.com/s/returntosport/PT/

You are invited to participate in a research project to identify current trends and controversies in the use of outcome measures to determine return to play readiness following ACL reconstruction.

An ACL rupture is a potentially athletic career ending injury. Reconstructive surgery is considered the gold standard management for athletes wishing to return to sport following an ACL injury. Unfortunately, standardized clinical practice guidelines do not exist to assist clinicians in making return to play decisions, and little consensus exists on which outcome measures best evaluate an athlete's functional status.

The survey consists of 10 closed format questions that include sections on demographics, outcome measures, treatment procedures, and return to sport decisions. The questionnaire should take 3-5 minutes to complete.

The primary goals of this study are:

1. To establish a baseline of current attitudes and practice amongst surgeons and physiotherapists in Canada in making return to play decisions following ACL reconstruction
2. To determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and

3. To gain a better understanding of how athletes and clinicians define successful return to sport and if any discrepancies in expectations exist between these groups.

This survey is being distributed to physiotherapists across Canada as part of a Master's research thesis project. Your participation may help inform the future development of Clinical Practice Guidelines in establishing return to play readiness in athletes following ACLR.

We are also asking for your assistance in recruiting eligible patients to answer a similar web survey which consists of 19 questions that include sections about their activity level, experience surrounding the process of rehabilitation after ACL reconstruction, and their decisions surrounding returning to sport. Our target population is athletes 18-50 years of age, having undergone ACL reconstruction within the last 6-18 months, and able to understand English. We would be grateful if you could post a printed copy of the attached advertisement for the study in your office between May 1, 2013 and July 1, 2013. The patient questionnaire is available for viewing at
http://fluidsurveys.com/s/returntosport/

Your participation is strictly voluntary, and all individual responses will be gathered anonymously. You may choose to discontinue the survey at any time.

Ethical approval was obtained by McMaster University for distribution of this survey, and a questionnaire consent form is available for your viewing. If you have any questions or concerns about this research project, contact the Principal Investigator Jacquie Minnes, at minnesjj@mcmaster.ca .

Letter of Information/Consent
http://fluidsurveys.com/s/consentinfo/

Thank you for taking the time to consider participating in this study.

Sincerely,

Jacquie Minnes MSc (Candidate), PT
McMaster University

Dr. Lucas Murnaghan, MD, MEd, FRCSC
University of Toronto

Appendix J.

McMaster University
Inspiring Innovation and Discovery

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

Physiotherapists

I have read the survey information form and consent to participate.

☐ **I consent** ☐ **I do not consent**

Please answer the following questions:

1. How many years have you worked as an orthopaedic physiotherapist?

    0
    1-4
    5-9
    10-14
    15-19
    20-24
    25+

2. Please check all of the qualifications which you have attained.

    BScPT/MScPT
    MSc
    PhD
    FCAMT/MScCl
    APP

3. How many ACLR patients do you see a year?

0-4
5-9
10-14
15-19
20-24
25+

4. Which standardized protocols do you use in designing treatment plans?

Fowler-Kennedy
Treating surgeon
Facility designed
Other
None

5. Which outcome measure(s) do you use to determine RTP readiness? Click all that apply.

Outcome Measure	**Do not use**	**Use, but does not influence RTP decision**	**Contributes to RTP decision**
IKDC Objective Subjective			
Tegner			
Lysholm			
Marx Knee Activity Scale			
ACL-RSI			
Jump tests			
ROM			
Lachman			
KT1000			
Pain			
Swelling			
Functional movement			
Subjective report of giving way			

6. What chronological timeline do you use for RTP following ACLR:

Minimum # months

Semitendinosis graft	3 4 5 6 9 12+
Bone-tendon-bone graft	3 4 5 6 9 12+
Allograft	3 4 5 6 9 12+

7. Do your RTP readiness decisions ever differ from those of the treating surgeon?

    Yes
    No

8. Do you feel confident making RTP decisions?

    Yes
    No

9. Is there a role for physiotherapists in making the primary RTP decision following ACLR?

    Yes
    No
    APP only

10. What measures do you feel describe successful RTP.

Statement	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
Functional stability							
Pain free with daily activities, unable to participate in sport							
Able to participate in a reduced level of sport							
Able to participate in pre-injury level of sport with functional limitations							
Able to participate in pre-injury level of sport with decreased performance							
Able to fully participate in pre-injury level of sport with no limitations or deficits							
Able to participate in any level of sport without pain							
Able to participate in any level of sport with pain							

Thank you for participating in this survey.

Appendix K.

McMaster University

Inspiring Innovation and Discovery

Follow-up Request
Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

Recently, you were invited to participate in a research project to identify current trends and controversies in the use of outcome measures to determine return to play readiness following ACL reconstruction.

If you have already completed the survey, thank you very much and please disregard this reminder message to participate in the web survey.

The survey consists of 10 closed format questions that include sections on demographics, outcome measures, treatment procedures, and return to sport decisions. The questionnaire should take 3-5 minutes to complete. Please click on the link below to participate in the survey WITHIN THE NEXT 7 DAYS.

An ACL rupture is a potentially athletic career ending injury. Reconstructive surgery is considered the gold standard management for athletes wishing to return to sport following an ACL injury. Unfortunately, standardized clinical practice guidelines do not exist to assist clinicians in making return to play decisions, and little consensus exists on which outcome measures best evaluate an athlete's functional status.

The primary goals of this study are:

1. To establish a baseline of current attitudes and practice amongst surgeons and physiotherapists in Canada in making return to play decisions following ACL reconstruction

2. To determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and
3. To gain a better understanding of how athletes and clinicians define successful return to sport and if any discrepancies in expectations exist between these groups.

This survey is being distributed to physiotherapists across Canada. The study is part of a Master's research thesis. Your participation may help inform the future development of Clinical Practice Guidelines in establishing return to play readiness in athletes following ACLR.

We are asking for your assistance in recruiting eligible patients to answer a similar web survey which consists of 19 questions that include sections about their activity level, experience surrounding the process of rehabilitation after ACL reconstruction, and their decisions surrounding returning to sport. Our target population is athletes 18-50 years of age, having undergone ACL reconstruction within the last 6-18 months, and able to understand English. We would be grateful if you could post a printed copy of the attached advertisement for the study in your office between May 1, 2013 and July 1, 2013. The patient questionnaire is available for viewing at **http://fluidsurveys.com/s/returntosport/**

All individual responses will be gathered anonymously and only group statistics will be compiled and reported.

Thank you for taking the time to consider participating in this web survey. A questionnaire consent form is available for your viewing. Ethical approval was obtained by McMaster University for distribution of this survey.

Letter of Information/Consent
http://fluidsurveys.com/s/consentinfo/

Sincerely,

Jacquie Minnes MSc (Candidate), PT
Faculty of Health Science, Rehabilitation Science
McMaster University
minnesjj@mcmaster.ca

Appendix L.

McMaster University

Inspiring Innovation and Discovery

Follow-up Request
Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

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The primary goals of this study are:

1. To establish a baseline of current attitudes and practice amongst surgeons and physiotherapists in Canada in making return to play decisions following ACL reconstruction

2. To determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and
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Letter of Information/Consent
http://fluidsurveys.com/s/consentinfo/

Sincerely,

Jacquie Minnes MSc (Candidate), PT
Faculty of Health Science, Rehabilitation Science
McMaster University
minnesjj@mcmaster.ca

Appendix M.

McMaster University

Inspiring Innovation and Discovery

Factors Used to Determine Unrestricted Return to Sport following Anterior Cruciate Ligament Reconstruction: A Nation-Wide Survey of Clinical Practice Guidelines

Surgeons

I have read the survey information form and consent to participate.

☐ **I consent** ☐ **I do not consent**

Please answer the following questions:

1. How many years have you been performing ACL reconstructions?

   0
   1-4
   5-9
   10-14
   15-19
   20+

2. How many primary ACLR do you perform per year?

   0-24
   25-49
   50-99
   100+

3. What is your primary choice of graft?

   Bone-tendon-bone
   Semitendinosis
   Allograft

4. What outcome measures do you use to determine RTP readiness? Please check all that apply.

Outcome Measure	Do not use	Use, but does not influence RTP decision	Contributes to RTP decision
IKDC Objective Subjective			
Tegner			
Lysholm			
Marx Knee Activity Scale			
ACL-RSI			
Jump tests			
ROM			
Lachman			
KT1000			
Pain			
Swelling			
Functional movement			
Subjective report of giving way			

5. What chronological timeline do you use for RTP following ACLR:

	Minimum
Semitendinosis graft	3 4 5 6 9 12+
Bone-tendon-bone graft	3 4 5 6 9 12+
Allograft	3 4 5 6 9 12+

6. Do you use a standardized RTP protocol?
   Yes
   No

7. Do you use a functional ACL brace for RTP following ACLR?

   Yes
   No

8. What percentage of primary ACLR that you perform need revision

   0-4%
   5-9%
   10-14%
   15-19%
   20-24%
   25%+

9. Is there a role for physiotherapists in making the primary RTP decision following ACLR?

   Yes
   No
   APP only

10. What measures do you feel describe successful RTP.

Statement	Strongly disagre	Disagre e	Somew hat	Neutral	Somew hat	Agree	Strongly agree
Functional stability							
Pain free with daily activities, unable to participate in sport							
Able to participate in a reduced level of sport							
Able to participate in pre-injury level of sport with functional limitations							
Able to participate in pre-injury level of sport with decreased performance							
Able to fully participate in pre-injury level of sport with no limitations or deficits							
Able to participate in any level of sport without pain							
Able to participate in any level of sport with pain							

Thank you for participating in this survey.

Appendix N.

McMaster University

Inspiring Innovation and Discovery

Dear COA Member, please see a message below from one of your colleagues.

Return to Play Decisions following ACL Reconstruction: McMaster Research Project

http://fluidsurveys.com/s/returntosport/ortho

Recently, you were invited to participate in a research project to identify current trends and controversies in the use of outcome measures to determine return to play readiness following ACL reconstruction.

If you have already completed the survey, thank you very much and please disregard this reminder message to participate in the web survey.

The survey consists of 10 closed format questions that include sections on demographics, outcome measures, treatment procedures, and return to sport decisions. The questionnaire should take 3-5 minutes to complete. Please click on the link below to participate in the survey WITHIN THE NEXT 7 DAYS.

An ACL rupture is a potentially athletic career ending injury. Reconstructive surgery is considered the gold standard management for athletes wishing to return to sport following an ACL injury. Unfortunately, standardized clinical practice guidelines do not exist to assist clinicians in making return to play decisions, and little consensus exists on which outcome measures best evaluate an athlete's functional status.

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2. To determine the differences in clinical variables (demographic, subjective, and psychological) between athletes who return to pre-injury level of sport participation, and those who do not at short term follow up, and
3. To gain a better understanding of how athletes and clinicians define successful return to sport and if any discrepancies in expectations exist between these groups.

This survey is being distributed to orthopaedic surgeons across Canada as part of a Master's research thesis project. Your participation may help inform the future development of Clinical Practice Guidelines in establishing return to play readiness in athletes following ACLR.

We are also asking for your assistance in recruiting eligible participants to answer a similar web survey which consists of 19 questions that include sections about their activity level, experience surrounding the process of rehabilitation after ACL reconstruction, and their decisions surrounding returning to sport. Our target population is athletes 18-50 years of age, having undergone ACL reconstruction within the last 6-18 months, and able to understand English. We would be grateful if you could post a printed copy of the attached advertisement for the study in your office between May 1, 2013 and July 1, 2013. The patient questionnaire is available for viewing at **http://fluidsurveys.com/s/returntosport/**

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Ethical approval was obtained by McMaster University for distribution of this survey, and a questionnaire consent form is available for your viewing. If you have any questions or concerns about this research project, contact the Principal Investigator Jacquie Minnes, at **minnesjj@mcmaster.ca.**

Letter of Information/Consent
http://fluidsurveys.com/s/consentinfo/

Thank you for taking the time to consider participating in this study.

Sincerely,

Jacquie Minnes MSc (Candidate), PT
McMaster University

Dr. Lucas Murnaghan MD, MEd, FRCSC
University of Toronto