Psychological Responses and Rehabilitation Outcomes Following Anterior Cruciate Ligament Reconstruction Surgery

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Hayley C. Russell

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Diane M. Wiese-Bjornstal

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Abstract

Theories of return to play following sports injury prescribe a multidimensional approach (Creighton et al., 2010) to determining when athletes are ready to resume participation, such as following anterior cruciate ligament (ACL) surgery and rehabilitation. Theories and evidence on psychological responses to injury show that cognitions such as knee self-efficacy and perceived recovery, affects such as fear of re-injury and depression/anxiety, and behaviors such as rehabilitation adherence are among the multidimensional factors predictive of return to play outcomes following ACL injuries (te Weirke et al., 2012). It is necessary for researchers to evaluate dynamic patterns of specific psychological responses across the time course of ACL rehabilitation in order to understand how they relate to outcomes such as return to play and perceived disablement. Therefore, the purposes of this study were twofold: (a) to determine if psychological responses to ACL injuries during the latter stages of rehabilitation were different between athletes that returned to play by nine months post-ACL surgery and those who did not, and (b) to assess if psychological responses at 4- and 6-months predicted perceived disablement at 9-months post-surgery. Participants (15 males, 17 females) were physically active individuals who had experienced ACL tears. Psychological measures repeated at 4-, 6-, and 9-months included knee self-efficacy, perceived percent recovery, perceived limitations to ability, mental health, and fear of re-injury. Outcome measures of perceived disablement and return to play status were completed at 9-months post-surgery. For the first purpose, analyses revealed that returners and non-returners differed on fear of re-injury at the 9-month assessment but not at 4- and 6-months post-surgery. Returners having lower levels of fear of re-injury

than non-returners at 9-months post-surgery. Returners also reporter higher levels of perceived recovery and lower perceived limitations to ability across ACL rehabilitation. For the second purpose, none of the psychological measures at 4-months post-surgery predicted 9-month disablement, while at 6-months perceived percent recovery inversely predicted disablement at 9-months post-surgery. Results reveal that psychological responses are important in determining rehabilitation outcomes post-ACL surgery.

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CHAPTER ONE

Introduction

"Only one goal is permissible in the care of the young athlete—namely, complete recovery; for, in the majority of cases of severe injury, especially to the knee, if the recovery is not complete, the patient is no longer an athlete."

—Don O'Donoghue (1950, p. 721)

In this quote Don O'Donoghue, a pioneer in the field of sports medicine, clearly identifies the importance of return to play when treating injured athletes. In order to return athletes to sport, O'Donoghue (1950) argues, health care professionals must ensure athletes have made a "complete recovery"; if not, they will be forced to retire – they will no longer be an athlete. In this classic paper, O'Donoghue identifies joint stability and being able to return to play as the two key ways to gauge success following surgical repair of the major ligaments of the knee; namely, the anterior cruciate ligament (ACL) and the medial cruciate ligament (MCL). If surgery and rehabilitation are unsuccessful, athletes may return to activities of daily living but he says, they are no longer athletes (O'Donoghue, 1950; Reider, 2012).

Sixty years after O'Donoghue's classic paper, great advances are evident in the treatment of knee injuries (Reider, 2012). Approximately 250,000 to 300,000 ACL injuries occur each year (Schub & Saluan, 2011) with approximately 200,000 reconstruction surgeries conducted annually in the United States (Reider, 2009). Physical outcomes, the first of O'Donoghue's indicators of success following ACL surgery, are overwhelmingly positive. Athletes perform well on physical tests of joint stability, strength, and range of motion post-surgery (Ardern Webster, Taylor, & Feller, 2011;

McCullough et al., 2012) with approximately 90% of athletes achieving normal or near normal functioning. However, when we examine the data on O'Donoghue's second characteristic of success following ACL reconstruction surgery, return to play, the results are far less positive. Many researchers have found that athletes who suffer ACL injuries and undergo subsequent ACL reconstruction surgery often do not return to their previous level of sport participation, or do so at a lower level (Ardern, et al., 2011; Brophy et al., 2012; McCullough et al., 2012). In fact, only approximately 50% of athletes who suffer ACL injuries return to play after surgery and rehabilitation (Ardern et al., 2011; Ardern, Webster, Taylor, & Feller, 2010; Kvist, Ek, Sporrstedt, & Good, 2005; Tripp, Stanish, Ebel-Lam, Brewer, & Birchard, 2007). Therefore, for many athletes who experience ACL tears they will not return to play, and in O'Donoghue's (1950) words will no longer be an athlete.

Theories of return to play suggest that failure to return often reflects a larger disability paradigm in which impairments and functional limitations impede athletes in returning to play, which negatively affects their quality of life (Vela & Denegar, 2010a). Logically, when returning an athlete to sport following ACL injury, the primary concern has been physical outcomes. According to a recent review of literature, health care professionals most often make return to play decisions based on time since surgery, muscle strength, general knee examinations (i.e., range of motion, effusion), hop tests, and stability (Barber-Westin & Noyes, 2011; Thomeé, et al., 2011). What is problematic; however, is that following ACL reconstruction surgery the vast majority of people achieves normal or near normal function on these assessed outcome measures yet do not return to play. Thus, these assessments may be overestimating the success of ACL

surgery and may not accurately determine athletes' readiness to return to play (Ardern et al., 2011).

Increasing attention has been paid to the psychological responses to injury that may be influential in determining an athlete's readiness to return to play after ACL injury (Ardern, Feller, & Webster, 2013a; Ardern et al., 2011; Creighton, Shrier, Shultz, & Meeuweisse; te Wierike, vander Sluis, van den Akker-Scheek, Elferink-Gemser & Visscher, 2013). Previous research has established that athletes report a variety of psychological responses to sport injuries that may influence their rehabilitation outcomes (Jevon & Johnston, 2003; Johnston & Carroll, 1998; McDonald & Hardy, 1990; Tracey, 2003; Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998). The integrated model of psychological response to sport injuries developed by Wiese-Bjornstal et al. (1998) is widely in sports medicine psychology research and recognizes three domains of psychological responses to sport injuries: (1) cognitive appraisal, (2) emotional or affective responses, and (3) behavioral responses, all influenced by personal and situational factors. According to the model, these psychological responses to injury can then influence physical and psychological outcomes of the injury such as return to play and quality of life. With specific attention to ACL injuries, a recent review of literature conducted by te Wierike and colleagues (2013) examined each of these response domains and their associations with ACL rehabilitation outcomes. te Wierike (2013) found support for the idea that cognitive, affective, and behavioral responses to injury are correlated with rehabilitation outcomes, specifically return to play in athletes with ACL injuries.

Addressing the discrepancy between the number of athletes who achieve success in subjective and objective physical rehabilitation outcomes compared to those who return to play is an important issue for two key reasons. First, athletes who undergo ACL surgery primarily do so with the intention of returning to sport and for most of these athletes, the idea of retirement from sport due to injury is a devastating prospect (Heijne, Axelsson, Werner, & Biguet, 2008). Second, athletes who retire from sport because of injury report lower physical and mental quality of life and life satisfaction post-retirement compared to athletes who retire from sport for other reasons (Kleiber & Brock, 1992; Kleiber, Greendorfer, Blinde, & Samdahl, 1987; Lavallee, Grover, & Gordon, 1997; Ochiai, Hagino, Tonotsuka, & Haro, 2011). As a result, researchers have begun to shift their focus from an exclusively biomedical view of ACL rehabilitation and return to play, to the concurrent examination of the impact of psychological responses in ACL injury outcomes (Creighton et al., 2010; McCullough et al., 2012; Reider, 2012).

Therefore, the first purpose of this study was to determine if there were differences between athletes who returned to play after ACL reconstruction surgery and those who did not return to play after ACL reconstruction surgery in terms of psychological responses to injury the latter part of rehabilitation and return to play. The second purpose of this study was to determine if psychological responses to injury at 4- and 6-months post-ACL reconstruction surgery would predict perceptions of disablement as an outcome of ACL rehabilitation.

The present study adds to the current literature in three key ways. First, the longitudinal, prospective design is unique to this study since the majority of researchers have examined psychological responses related to return to play retrospectively (Kvist et

al., 2005; Tripp et al., 2007), cross-sectionally (Chmielewski et al., 2008), or only at time points early in rehabilitation (Brewer et al., 2007; LaMott, 1994). The present design allowed for assessment of the chronology of psychological responses through the latter part of rehabilitation following ACL reconstruction surgery – a period of time not yet well understood. Second, previous literature has often used measures not specifically designed for sport (Tripp et al., 2007) perhaps not accurately measuring the athlete-specific responses and challenges. Third, return to play has typically only been studied as a dichotomous variable, in this project; however, we extended the exploration of return to play into the broader context of disablement. In the following chapter, I review the relevant literature related to the incidence of ACL injuries, as well as physical and psychological readiness to return to unrestricted activity following ACL reconstruction. I also consider relevant theoretical frameworks explaining the relationships between psychological responses and return to play outcomes and conclude with the purposes of the present study.

Review of Literature

Anterior Cruciate Ligament (ACL) Injuries

A tear of the ACL is a costly injury that results in physical and psychological discomfort and extensive time away from sport and physical activity. The ACL is one of four key stabilizing ligaments of the knee. The primary purpose of the ACL is to prevent the anterior glide of the femur on the tibia. Tears to the ACL are relatively common in sport and physical activity, and typically occur through twisting, pivoting, or cutting (Ardern, Taylor, Feller, & Webster, 2012). Approximately 250,000 to 300,000 ACL tears occur annually in the United States (Schub & Saluan, 2011). The incidence of ACL

injuries in the highest risk population (individuals aged 16-39) is 80 cases per 100,000 people in the United States (Sanchis-Alfonso & Monllau, 2013). In collegiate sport, the incidence rate is approximately 0.15 per 1000 athlete exposures (Hootman, Dick, & Agel, 2007). ACL tears often negatively affect the functional abilities of athletes because of pain, swelling, and instability in their knee joints (Hughes & Watkins, 2000; Samuelsson, Andersson, & Harlsson, 2009).

An ACL deficient knee is associated with functional defects, as well as increased risk of later injury, and can lead to early onset of degenerative changes (Samuelsson et al., 2009). ACL reconstruction surgery is performed to prevent these negative symptoms and outcomes. This surgery is typically performed arthroscopically by replacing the torn ACL with a hamstring tendon or patellar tendon autograft (Lind & Pedersen, 2013; Myklebust & Bhar, 2005).

Athletes often perceive ACL reconstruction surgery as the only way to continue participation in sport after suffering an ACL tear (Heijne et al., 2008). In their qualitative examination of athletes after ACL injury, Heijine and colleagues (2008) found that there was no dilemma for athletes as to whether or not to undergo ACL reconstruction surgery – if they wanted to play a sport again they needed to have the surgery. Athletes' choices of non-operative treatment was seen as resignation that they would never return to their pre-injury physical activity level. One participant indicated that "it was more like I had the surgery because I wanted to become a 'whole person'" (Heijine et al., 2008, p. 328). Thus, the typical course of treatment for an ACL tear for an active individual involves reconstruction surgery (i.e., replacing the torn ACL with a graft; Lind & Pedersen, 2013; Myer, Paterno, Quatman & Hewett, 2006).

ACL reconstruction surgery is followed by a lengthy rehabilitation protocol lasting four to twelve months. The goal of rehabilitation is to restore function and return athletes to their previous levels of activity (Myer et al., 2006). During the first weeks of rehabilitation from ACL reconstruction surgery, the objectives of the rehabilitation protocol are to reduce pain and swelling in the injured knee while improving range of motion and regaining control of the quadriceps and hamstring. By three to four months post-surgery, athletes typically begin working on strength, power, and endurance activities and begin running. Full return to previous activity is anticipated by six to nine months after surgery (Delay, Smolinski, Wind, & Bowman; 2000; Heijne et al., 2008; Stoehr, Mayr, Wondrasch, & Fink, 2014).

Theories of Return to Play

Considering most athletes undergo ACL rehabilitation in order to return to their pre-injury level of sport participation (Heijne et al., 2008), it is not surprising that one of the most important questions athletes have during rehabilitation from ACL reconstruction surgery is when they can return to play (Myklebust & Bahr, 2005). Return to play is defined as "medical clearance of an athlete for full participation in sport without restriction (strength and conditioning, practice and competition)" (Creighton et al., 2010, p. 380). There are two major questions to be answered with respect to return to play after rehabilitation from ACL reconstruction surgery – if and when.

According to Vela and Denegar (2010a) whether or not an athlete returns to play post-sport injury is couched in a broader disablement model along with other potential outcomes. When assessing outcomes of injuries Denegar, Vela, and Evans (2008) suggest a disablement paradigm is appropriate to examine impairment, functional

limitation, disability, and quality of life post-injury. Disablement is defined as "the sequence of interrelated but discrete events that take place as a result of pathology, and ultimately it leads to disability or participation restriction" (Denegar et al., 2008, p. 340). Essential to understanding disablement is the idea that pathology, in this case an ACL tear, impacts an athlete on multiple levels including the site of the injury, the person as a whole, and the person in the greater context of society (Denegar et al., 2008).

Vela and Denegar (2010a) conducted a mixed methods investigation to develop a disablement model specifically for physically active populations. In this study, they identified impairments, functional limitations, disability limitations, and changes to quality of life specific to injured athletes. They used this information to develop a descriptive model of disablement in a physically active population. Like previous disablement paradigms, Vela and Denegar categorized events that athletes experience after an injury, from a local to a more global level. At the most local level, athletes identified four themes that were impairments related to their injury – pain, decreased motion, decreased muscle function, and instability. With respect to functional limitations, athletes identified skill performance, daily actions, maintaining positions, fitness, and changing directions as being problems for them post-injury. At the disability level, athletes reported problems participating in their sport or physical activity of choice. At the quality of life level, participants indicated problems with uncertainty and fear, stress and pressure, mood and frustration, energy, and altered relationships. In the case of an ACL injury, an athlete could experience knee-related symptoms, such as pain or instability. These localized symptoms could then lead to functional limitations, such as not being able to run, and this functional limitation could lead to disability – not returning

to sport. This disability then negatively affects an athlete's overall quality of life such as problems with mood and social relationships (Denegar et al., 2008; Vela & Denegar, 2010a, see Figure 1).

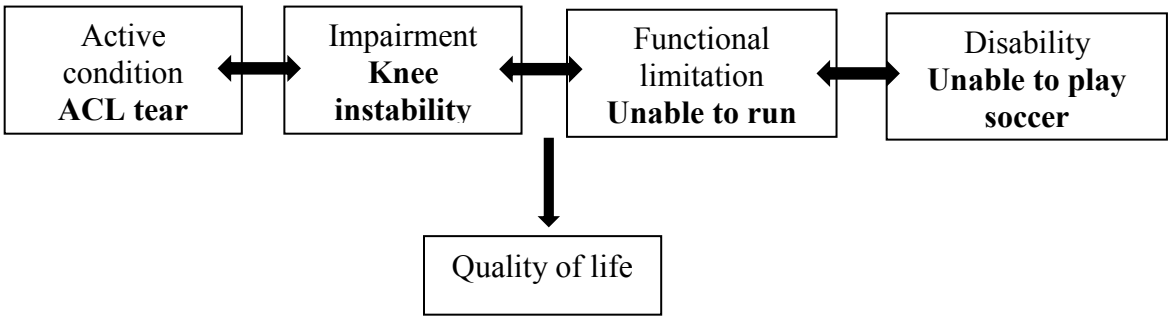

Figure 1. Disablement model for an ACL tear. Adapted from "Transient Disablement in the Physically Activity With Musculoskeletal Injuries, Part I: A Descriptive Model" by L. I. Vela and C. Denegar, 2010, *Journal of Athletic Training, 45*, p. 616. Copyright by National Athletic Trainers' Association, Inc.

The disablement model developed by Vela and Denegar (2010a) highlights both the influential physical factors that may lead athletes to experience disability (e.g., not returning to play) after a sport injury, as well as the potential quality of life implications of experiencing disablement post-injury. ACL rehabilitation focuses on minimizing impairments and functional limitations in order to prevent disablement and support return to play post-ACL surgery (Delay et al., 2000; Stoehr et al., 2014). Once ACL rehabilitation is complete, health care professionals must answer the second question related to return to play – when is an athlete ready to return to play?

Health care professionals are charged with the responsibility of managing athletes' motivation to return to play, while minimizing their risk of future injury and maximizing their chances for athletic success (Ardern et al., 2013a). Yet models and theories of readiness to return to play are limited (Podlog & Eklund, 2007). Even models

designed to explain return to play have offered somewhat vague instructions as to how to achieve physical and psychological readiness to return to play and when to medically clear athletes for return to play. For example, according to Taylor and Taylor's (1997) model, developed based on clinical practice, return to play consists of five stages: (1) "initial return" (p. 266), (2) "recovery confirmation" (p. 267), (3) "return of physical and technical abilities" (p. 269), (4) "high intensity training" (p. 269), and (5) "return to competition" (p. 270).

The first stage of the return to sport model is *initial return*. This stage is when athletes first test their injured areas in sport specific training. It is described as the most psychologically taxing, where athletes may have unrealistic expectations, experience external pressure, and be overzealous about their return to play. Once athletes have moved on from the initial return they move on to the second stage of this model – *recovery confirmation.* In the recovery confirmation stage, athletes should have received reinforcement from their initial return that their injured area is ready to face the demands of competitive sport. During this phase, Taylor and Taylor (1997) note that athletes' confidence and motivation should increase and their anxiety, depression, and other negative emotions should decrease. The third stage of this model is the *return of physical and technical abilities.* This stage is characterized by athletes re-establishing their physical and technical competence related to sport. According to Taylor and Taylor, this stage marks the conclusion of formal rehabilitation and again can be associated with athletes being overzealous in their training. The fourth stage is *high intensity training.* According to Taylor and Taylor, this stage marks the conclusion of athletes identifying as being injured. Athletes in this stage should be highly motivated and have psychological

characteristics at or above pre-injury levels. Finally, stage five is *return to competition.* During this stage, athletes may experience both anticipation and concern. Taylor and Taylor (1997) argue that once an athlete has moved through these stages of return to play, they are ready for unrestricted clearance for activity. This model; however, assumes athletes respond to and recover from injuries in linear and sequential manner. In this model, Taylor and Taylor do not provide explicated instructions as to how to improve outcomes or to account for individual differences to determine when a specific athlete is ready to return to play (Podlog & Eklund, 2007).

More specific to the multidimensional considerations for returning an athlete to play post-injury, Creighton and colleagues' (2010) have developed a return to play decision-based model to aid health care professionals in determining when an athlete is ready to return to their pre-injury activities. In this model, Creighton and colleagues indicate that the decision to return to play is a 3-step process. This process begins with step 1 – the evaluation of health status. The authors indicate that this is the most important component of the return to play decision. This step includes evaluation and consideration of demographic and medical factors including medical history, current symptoms, and psychological state. Step 2 is the evaluation of participation risk. This step includes consideration of competitive level, sport type and position played. Step 3 includes consideration of decision modifications, factors such as internal and external pressure, timing and season. Creighton and colleagues' model provides a strong theoretical framework for the importance of considering multidimensional health when medically clearing an athlete to return to play following injury.

From these three models of return to play post-injury (Creighton et al., 2010; Taylor & Taylor, 1997; Vela & Denegar, 2010a) we can see that return to play is a complex and multidimensional process characterized by a variety of physical and psychological responses and outcomes. In order for athletes to successfully return to play the elements identified in each of these models need to be evaluated and considered.

Physical readiness to return to play. As indicated in Creighton and colleagues' (2010) decision-based model of return to play, evaluation of health status is the most important component of the decision to return an athlete to sport. Specifically, medical clearance to return to unrestricted activity following ACL reconstruction surgery primarily involves assessment of physical criteria. In a recent review of the literature, Barber-Westin and Noyes (2011) identified the published criteria health care professionals use to return athletes to unrestricted activity after ACL reconstruction surgery. The authors found that the most common criterion for returning a patient to activity was time since surgery. Specifically, most articles reviewed indicated that 6 months post-surgery was an appropriate time to return to play. Time since surgery was followed by assessment of subjective criteria (e.g., subjective assessment of knee function) as the second most commonly used indicator of when an athlete is ready to return to play post-ACL surgery. Example of subjective assessments included regaining full functional stability and satisfactory performance of sport specific skills.

Objective criteria in combination with time since surgery was the third most common measurement category used to determine when athletes were ready to return to unrestricted activity. Muscular strength was the most commonly cited objective criterion used for returning athletes to unrestricted activity (Barber-Westin & Noyes, 2011). They

indicated in their review that recommendations for muscular strength of the hamstrings and quadriceps ranged from 80% to 90% of contralateral leg, with some researchers suggest that as little as 70% may be an acceptable degree of strength to return to play (Thomeé et al., 2011). Limb symmetry is also used as an indicator of muscular strength to determine readiness to return to play. Barber-Westin and Noyes (2011) indicate that measurements of the circumference of the thigh that showed less than .05-1 centimeters difference between legs were required for an athlete to return to play. Thomeé et al. (2011) indicate that a limb symmetry index of less than 90%, meaning a greater than 10% difference between legs, is unacceptable for return to play. The second most common objective evaluative criterion for returning athletes to sport following ACL reconstruction surgery was a general knee examination (Barber-Westin & Noyes, 2011). A general knee examination involved assessment of effusion (i.e., swelling) and/or range of motion. When these criteria were used to determine readiness to return to play, the expectations were that the athlete has no effusion and full range of motion. Single-leg hop was the third most common objective criterion in the studies reviewed by Barber-Westin and Noyes (2011). Thomeé et al. (2011) also indicated this was an important indicator for readiness to return to play following ACL reconstruction, conducted within a battery of assessments including leg extension, leg flexion and leg press. Again, Thomeé et al. suggest that patients should have at least 90% of the performance of the uninjured leg in assessments of vertical jump, hop for distance, and side hop before clearance to return to activity.

The fourth and final category of criteria that Barber-Westin and Noyes (2011) identified in the literature as a way to determine readiness to return to play following

ACL reconstruction surgery was knee stability. The benchmark for readiness to return to play based on knee stability was a negative Lachman test. A Lachman test is often performed to diagnose an ACL tear and is a measure of ligament laxity. A negative Lachman test suggests good ligament stability (Logan, Williams, Lavelle, Gedroyc, & Freeman, 2004) and thus suitability for return to play.

Somewhat consistent with Barber-Westin and Noyes' (2011) review, a recent survey of experienced arthroscopic surgeons by Petersen and Zantop (2013) found many similar criteria for medical clearance for return to play. Specifically, they found post-operative time to be an important factor in the decision to return athletes to sport following ACL reconstruction surgery. Petersen and Zantop found that the Lachman test was the most often reported criterion for returning athletes to play. The next most commonly cited criteria included assessments of range of motion, negative pivot shift, anterior drawer test, proprioceptive tests, hop tests and assessment of muscular strength.

Overall, researchers have indicated that there is a lack of standardized assessments to determine physical readiness to return to play after ACL reconstruction surgery (Barber-Westin & Noyes, 2011, 2013; Renström, 2012). Lack of standardized and evidence-based return to play criteria is problematic as premature return to play has been associated with increased risk of subsequent knee injury (Barber-Westin & Noyes, 2013). Moreover, even when athletes meet benchmark physical criteria for returning to sport after ACL injury they are not necessarily ready to return to play and thus may not be successful (Langford, Webster, & Feller, 2009).

It has become increasingly evident that clinic-based physical criteria alone may not be adequate to determine if patients are ready, and will be successful, in their return

to play or physical activity. Reconstruction ACL surgery generally results in positive physical outcomes such as athletes achieving normal or near normal strength, range of motion, and joint laxity (Ardern et al., 2011). Nevertheless, the rates of return to previous level of sport participation are alarmingly low. Generally, researchers have reported that around 50% of athletes return to their previous level of play following ACL reconstruction surgery (Ardern et al., 2011; Kvist, 2004, 2005; Langford et al., 2009). A recent meta-analysis of return to play after ACL injuries revealed that although over 80% of participants initially returned to play, only 63% of those 80% did so at their self-reported previous level of participation. Moreover, only 44% of the 80% continued participation at final follow up despite the fact that 90% of the overall population had normal or near normal knee function based on physical assessments such as strength and joint laxity (Ardern et al., 2011). Given that the vast majority of athletes meet physical outcome clinical expectations following ACL surgery, the low return to play statistics suggest that clinic-based physical readiness is not synonymous with either sport-based or psychological readiness to return to play.

Brophy and colleagues (2012) examined return to play statistics in a study of male and female adult soccer players who experienced ACL injuries. At one-year follow up post-surgery, 72% of players had returned to play and 85% of those players were at the same or a higher level of play. At seven-year follow up, however, only about 35% of athletes had continued to play soccer. The authors noted that it was unknown if this lower participation differed from athletes without injuries. At this follow-up, however, 56% of women and 26% of men attributed their cessation of competitive play to their ACL injury. The statistics on return to play indicate a disconnection between clinical

readiness and real world readiness to return to play. Therefore, additional factors, beyond physical readiness demand consideration in order to maximize return to play success.

Theory of Psychological Responses to Sport Injury

In their review of the literature, Doyle, King, and Wilson (2013) determined that readiness to return to play after ACL reconstruction surgery was influenced by myriad factors, including operative style, rehabilitation program, age/gender, and psychological factors. Increasingly, attention has been paid to psychological responses that may influence an athlete's readiness to return to play following ACL reconstruction surgery as well as their success in returning (Nyland & Brand, 2013). Therefore, it is important that health care professionals incorporate other components of Creighton and colleagues' (2010) decision based model of return to play when making the decision to medically clear and athlete for unrestricted activity.

For example, another important component of Creighton and colleagues' (2010) decision based model of return to play that should be considered when medically clearing an athlete to return to play is psychological state. Like physical assessments, psychological state is in step 1, of Creighton and colleagues' model and thus should be considered among the most important criteria in returning an athlete to sport. Specifically, Creighton et al. indicate that readiness, or confidence, about returning to play, are important indicators of whether athletes is ready to return to activity. This is an important consideration in the return to play decision as researchers have consistently demonstrated that the impact of an ACL injury on an athlete is not just physical. Researchers have found that almost all athletes experience some sort of psychological response (often negative) to a sport related injury. Not only can this psychological

response to injury create psychological distress for athletes but it can also influence physical well-being and return to play success (Jevon & Johnston, 2003; Johnston & Carroll, 1998; McDonald & Hardy, 1990; Tracey, 2003; Wiese-Bjornstal et al., 1998).

In their integrated model, Wiese-Bjornstal and colleagues (1998; see Figure 2), provided a theoretical framework for understanding the relationship between psychological responses and rehabilitation outcomes including return to play. Wiese-Bjornstal and colleagues propose that psychological responses to sport injury fall into three categories: (1) cognitive appraisal of the injury, (2) emotional responses, and (3) behavioral responses to the injury. According to this model, pre-existing personal factors (e.g., age, injury type, history of injury) and situational factors (e.g., level of play, time in season, social influences), affect an athlete's cognitive appraisal of the injury. For example, in appraising the injury, an athlete might think, "This is the worst thing that has ever happened" or alternatively, "I can cope with this injury." The athlete's cognitive appraisal of an injury then influences emotional responding (e.g., sad, scared, angry, confused) and in turn behavioral responses (e.g., avoidance of teammates, adherence to treatment). Ultimately, these three factors – cognitive appraisal, emotional response, and behavioral response – interact reciprocally to influence the physical (e.g., strength, stability, range of motion, return to play) and psychological outcomes (e.g., quality of life, psychological growth).

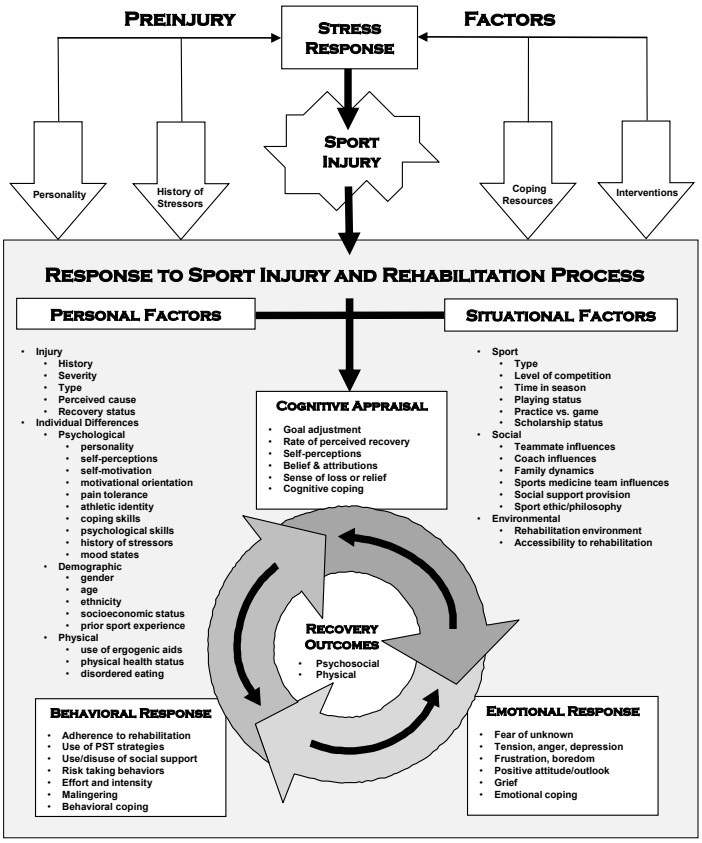

Figure 2. Integrated model of psychological response to the sport injury and rehabilitation process. Adapted from "An Integrated Model of Response to Sport Injury: Psychological and Sociological Dynamics," by D. M. Wiese-Bjornstal, A. M. Smith, S. M. Shaffer, and M. A. Morrey, 1998, *Journal of Applied Sport Psychology, 10*, p. 49. Copyright 1998 by Taylor & Francis.

Psychological Responses to ACL Injuries

Based on Wiese-Bjornstal et al.'s (1998) integrated model, it is expected that athletes with different types of injuries (a personal moderating factor in the model) could have different psychological responses and outcomes post-injury. Given the relative frequency and considerable impact (surgical, rehabilitation, time lost from training) involved, the psychological responses to ACL injuries have garnered significant attention in sport medicine psychology research (Langford et al., 2009; Nyland & Brand, 2013; te

Wierike et al., 2013). Researchers have found a number of consistent psychological responses to ACL injuries. For example, athletes who experience ACL injuries and subsequent surgery tend to experience negative mood (Brewer et al., 2007; Morrey, Stuart, Smith, & Wiese-Bjornstal, 1999; Tripp et al., 2007), fear of re-injury (Chmielewski, et al., 2008; Heijne et al., 2008; Kvist, et al., 2005; Tripp et al., 2007), and reductions in athletic identity (Brewer & Cornelius, 2010).

The results of this primarily quantitative research have been supported by qualitative research that has added to the understanding of psychological responses to ACL injuries. Brewer, Van Raalte, and Cornelius (2006) conducted a qualitative analysis of online message boards devoted to ACL injuries. They found athletes had many concerns after ACL injuries. The most common concerns were rehabilitation progress, pain, complications of surgery, physical therapy, diagnosis, return to play, whether to have surgery, and concerns related to surgery. Heijne et al. (2008) conducted semi-structured interviews with athletes who had undergone ACL reconstruction surgery. They found that athletes underestimated the difficulty and duration of ACL rehabilitation and reported this to be a source of frustration. Athletes also reported struggling to maintain motivation throughout the rehabilitation. Finally, the majority of participants reported they did not think they were fully recovered a year after surgery and felt decreased confidence in their injured knee.

Carson and Polman (2008) have provided further qualitative support for the psychological responses of athletes after ACL injuries. Carson and Polman conducted a case study of a professional male rugby player who experienced an ACL tear. They found that this particular athlete experienced “apprehension, anger, and

depression/frustration" (p. 75) prior to surgery. Following surgery, the athlete reported experiencing "relief and anxiousness" (p. 75). During the initial rehabilitation, he again experienced apprehension. As the latter phase progressed, he experienced depression and frustration. Finally, during the return to play phase, the athlete experienced increased confidence, apprehension, and relief. Overall, researchers have found through the use of various methodologies that athletes report many psychological responses to ACL injuries. Although some positive psychological responses have been reported (e.g., increased confidence, relief) most responses are negative (e.g., fear, depression, anger).

Chronology of emotional responses to ACL injuries. Researchers, through both qualitative and quantitative research, have found support for the psychological responses to injuries presented in the integrated model of psychological response to sport injury (Wiese-Bjornstal et al., 1998, 2012) with respect to ACL injuries. The integrated model, however, does not explicitly describe the chronology of responses to injuries. Generally, psychological responses to sport injury are dynamic, meaning the responses have ups and downs throughout the rehabilitation process (Wiese-Bjornstal, 2004). Wiese-Bjornstal (2004) described the psychological responses to sport injury as like a Slinky® in that it is an ever-changing process with psychological responses spiraling up and down as the athlete experiences rehabilitation progress and setbacks. There is conflicting evidence, however, as to the chronology of psychological responses to ACL injuries.

Limited longitudinal research has been conducted to examine the chronology of psychological responses to ACL injuries. Results of these studies have provided no clear picture of how the psychological responses to ACL injuries change over time. Some

researchers have found support for the idea that psychological distress decreases consistently over the course of rehabilitation while others have provided support for the idea of psychological responses being dynamic throughout the rehabilitation process with increased psychological distress likely during return to play. Langford et al. (2009) used a prospective longitudinal design to examine negative emotional responses to injury of athletes with ACL injuries at 3-, 6-, and 12-months post-operatively. By 12-months post-surgery, 51% of participants had returned to full competition. Langford and colleagues found that negative emotional responses to injury decreased linearly over time and that athletes felt increasingly positive about return to play as they progressed through rehabilitation. They assessed emotional responses using a researcher-developed instrument called the ACL Return to Sport Inventory that measures psychological responses to return to play after ACL injury.

Chmieleski et al. (2008) also suggested there is a significant linear reduction in psychological distress across the course of ACL rehabilitation. With a cross-sectional design Chmieleski and colleagues assessed fear of re-injury and perceived recovery at less than 90 days post-surgery, between 91 and 180 days post-surgery and between 181 and 372 days post-surgery. They found that fear of re-injury decreased significantly and linearly based on time since surgery and was inversely associated with health care professional assessed function in each group. The authors concluded that this supports the idea of a decrease in psychological distress, specifically, fear of re-injury, and an increase in perceived recovery across ACL rehabilitation.

Brewer and colleagues (2007) also found evidence of a linear decrease in psychological distress throughout ACL rehabilitation. These authors had participants

keep daily logs of their pain and negative mood following their ACL reconstruction surgery. Adult competitive athletes were tracked for the first six weeks post-ACL surgery. Brewer and colleagues found that during the first six weeks of rehabilitation, pain levels decreased significantly and faster as time went on. Daily negative mood also decreased significantly during the data collection period. The study was limited, however, by the limited follow-up time (i.e., six weeks) so it cannot be assumed that this linear pattern of reduction in psychological distress would continue over the course of a lengthier ACL rehabilitation.

In contrast to the findings of Langford et al. (2009), Chmieleski et al. (2008) and Brewer et al. (2007), other researchers have found support for a more dynamic pattern in psychological distress following ACL surgery. In one of the first longitudinal studies of psychological responses to ACL injuries, LaMott (1994) examined psychological changes across ACL rehabilitation as compared to non-injured controls. LaMott found that although pain and helplessness decreased across the course of rehabilitation in the injured group, perceptions of boredom and frustration increased across the first 12 weeks of ACL rehabilitation. An "emotional U" pattern was also identified where negative emotions decreased from pre-surgery to 6 weeks post-surgery but then increased again at 12 weeks post-surgery.

Morrey Stuart, Smith, and Wiese-Bjornstal (1999) also conducted a prospective, longitudinal study following athletes with ACL injuries 6 months after surgery, as compared to LaMott's (1994) 12 weeks, to assess the psychosocial and physical recovery of athletes. Consistent with LaMott, Morrey et al. identified an "emotional U" pattern. Athletes experienced increased mood disturbance immediately after surgery. This mood

disturbance subsequently decreased and then increased again at six-months post-operatively in the injured competitive athlete group. Morrey and colleagues indicate that 6-month post-surgery is an important milestone during ACL rehabilitation because, at this point, athletes tend to increase sport-specific training and become closer to returning to play.

There is conflicting evidence whether psychological distress decreases linearly or dynamically throughout ACL rehabilitation; however, there is evidence that the period of return to play may be associated with increases psychological distress. Most relevant to the specific focus of the present project, Creighton and colleagues (2010) argue that biological, psychological, and functional factors must be taken into account when health care professionals are making return to play decisions. This is especially important as psychological responses such as fear and anxiety can lead athletes to a higher risk of re-injury upon return to play (Creighton et al., 2010; Glazer, 2009).

Researchers have repeatedly demonstrated that, when athletes prepare to return to play after an ACL injury, they have mixed emotions associated with this decision. Podlog and Eklund (2006) conducted retrospective interviews with semi-professional male and female athletes (some with ACL injuries, some with other serious injuries). The authors found that return to play after injury was an emotional experience for athletes, who reported positive and negative emotional responses during return to play. Positive emotions related to return to play included excitement about getting to play their sport again and anticipation of the positive aspects of sport. Negative emotions related to return to play included anxiety about re-injury, meeting sport related goals, self-presentation, and letting down coaches and teammates. Moreover, Podlog and Eklund

(2005) noted that athletes, especially those who are more extrinsically motivated than intrinsically motivated to return to play, showed increased worry and concern associated with return to play. Although it is often assumed that return to play after ACL injuries is associated with excitement and anticipation it is important to note that research indicates there may also be negative psychological responses associated with return to play process that may impede an athlete's ability to successfully return to play.

Psychological responses related to return to play. Researchers have identified a number of specific psychological responses that are associated with unsuccessful return to play after ACL injuries. As indicated by Morrey et al. (1999) and Podlog and Eklund (2005, 2006), not only are psychological responses to knee injuries perhaps intensified at the phase of return to play, but these psychological responses have been found to have implications for physical injury outcomes, such as influencing if an athlete will be successful in returning to play. As previously stated, Wiese-Bjornstal et al.'s (1998, 2012) integrated model suggests that cognitive appraisals, emotional responses, and behavioral responses change over time and interact to influence physical and psychological outcomes post-injury. Brewer, Andersen, and Van Raalte (2001) extended this further in their biopsychosocial model of sport injury rehabilitation. They specify that the psychological responses as well as biological and social contextual factors post-injury interact to influence both the intermediate biopsychological outcomes of the injury (e.g., range of motion, pain and rate of recovery), as well as sport injury rehabilitation outcomes (e.g., quality of life and readiness to report to sport). This connection between both intermediate biopsychological outcomes and sport injury rehabilitation outcomes

and psychological responses has been shown to have important implications for athletes with ACL injuries, specifically with respect to successful return to play.

Cognitive. In her model of psychological response to sports injuries Wiese-Bjornstal (2010) described cognitive responses to injuries as interpretations, appraisals, and beliefs experienced post-injury. With specific attention to ACL injuries, te Wierike et al. (2013) identified self-efficacy associated with ACL rehabilitation outcomes.

Knee self-efficacy. Self-efficacy is defined as a person's belief in their ability to perform a specific task. In the case of athletes with ACL injuries, knee self-efficacy refers to athletes' perceived ability of their knee to perform the tasks necessary to participate in sport of physical activity (Thomeé et al., 2007). In his development of self-efficacy theory, Bandura (1977) suggested that if a person has sufficient skills and motivation to perform a task, self-efficacy will be the major determinant of whether or not the person actually performs that task. According at Bandura (1977), self-efficacy is influenced by a number of sources including: past performances, vicarious experiences, verbal persuasion, and imaginal experiences. In the context of sport injury, knee self-efficacy refers to athletes' beliefs that the knee will be able to support their ability to execute specific movement tasks. It has been found to be a predictor of success in returning to play after ACL injury (Thomeé et al., 2007).

Thomeé et al. (2007) assessed knee self-efficacy, physical activity, and knee related symptoms pre-operatively and at 3, 6, and 12 months post-operatively in an ACL injured population. Knee self-efficacy increased significantly at each time point post-surgery. Younger participants (17-29 years of age) and men had higher self-efficacy scores than older participants (aged 30 years and older) and women. Knee symptoms

such as pain, swelling, and instability, also decreased significantly over time. There were low correlations between self-efficacy and knee symptoms at 3 months post-surgery and moderate to strong correlations between self-efficacy and knee symptoms at 12 months post-surgery.

Thomeé et al. (2008) continued their research on knee self-efficacy and physical functioning by conducting a study to determine if knee self-efficacy pre-ACL reconstruction surgery would be associated with knee function one year post-surgery in individuals who had experienced ACL tears during sport. They found that knee self-efficacy post-injury but prior to surgery predicted physical activity, symptoms, and muscle function one year post-operatively. Specifically, the intensity and frequency of participants' physical activity one year post-surgery was predicted by their pre-surgery level of knee self-efficacy. Higher self-efficacy was associated with more frequent and higher intensity activity. Thomeé et al. also found that participants with higher pre-surgery self-efficacy perceived their knee related symptoms to be less severe and their knee related quality of life to be higher one-year post surgery.

Thomeé et al. (2010) continued their research on knee self-efficacy by conducting a randomized controlled intervention to determine if a rehabilitation program aimed improving self-efficacy would improve physical rehabilitation outcomes of patients (ranging in age from 16-53) who had undergone ACL surgery. Participants in the treatment group received physical therapy from a physical therapist trained in a rehabilitation model based on Bandura's self-efficacy theory. Results indicated that both groups – treatment and control – had significantly lower levels of physical activity at 12 months post-injury as compared to pre-injury. Participants in both groups had

significantly higher knee self-efficacy levels at 12-month follow-up as compared to immediately post-surgery. No between-group differences were found for physical activity level or self-efficacy between the experimental and control groups. This study however, had a very small sample size (12 in each group) with great variability in age and activity level, all of which may have influenced the results. In summary, knee self-efficacy has been found to be associated with physical function outcomes at 12 months post-surgery when assessed prior to surgery and at 3, 6, and 12 months post-surgery.

Perceived recovery. Perceived recovery is operationally defined as an athlete's perception of their progress towards full recovery. Perceived recovery has been identified in qualitative research as an important attribution as to why athletes return or do not return to play post-ACL reconstruction surgery. In their assessment of athletes at 12 to 25 months post-ACL reconstruction surgery, Flanigan, Everhart, Pedroza, Smith, and Kaedling (2013) conducted telephone interviews and asked participants to self-report if they had returned to sport since their ACL reconstruction surgery. If they had not returned to sport they asked them to identify factors that they thought influenced their decreased activity level post-injury. In this study, 54% of participants did not return to their pre-injury level of activity. The most commonly cited reason for not returning to their pre-injury activity was the perception of having not made a complete recovery from the injury. They specifically cited knee symptoms indicative of an incomplete recovery, including pain, swelling, and instability. Sixty-eight percent of participants indicated these were limiting factors in returning to sport. The second most common reason for not returning to sport was choosing to no longer participate, with 63% of participants indicating this contributed to them not returning to sport. Fear of re-injury was the third

most common reason for not returning to sport with 52% of participants indicating fear of re-injury contributed to them not returning to sport. Far fewer participants indicated advice from surgeons, lack of interest in returning to sport, life related issues, and non-knee health related issues as the reasons for them not returning to sport after ACL reconstruction surgery.

Affective. In her consensus statement on the psychological risk, response, and recovery from injury, Wiese-Bjornstal (2010) defined affective responses to sport injuries as inclusive of emotions, feelings, and moods experienced post-injury. With specific attention to ACL injuries, te Wierike and colleagues (2013) identified a number of affective responses to ACL injuries that have been found to be associated with outcome of ACL reconstruction surgery including fear of re-injury and mood state.

Fear of re-injury. Fear of re-injury has been referred somewhat interchangeably in the literature as kinesiophobia (Kori, Miller & Todd, 1990; Tripp et al., 2007) and as re-injury anxiety (Walker, Thatcher, & Lavallee, 2010). Kinesiophobia is defined as "an irrational and debilitating fear of physical movement resulting from a feeling of vulnerability to painful injury or re-injury" (Kori et al., 1990, p. 37) and is more commonly used in patients with chronic pain. The construct does not necessarily refer specifically to sport and physical activity but more commonly refers to activities of daily living (Kori et al., 1990). Walker and colleagues (2010) argue for the use of the term re-injury anxiety compared to fear of re-injury because anxiety is the feeling associated with what could happen whereas fear is associated with what is actually happening at the present moment. For the purposes of this paper, the terms fear of re-injury and re-injury

anxiety are used interchangeably and in a manner consistent with the authors' usage in the reviewed literature.

Return to play can be seen as either a threat or a challenge. If athletes perceive return to play as a threat, they are more likely to avoid returning and thus avoid the perceived dangers associated with return to play (Taylor & Taylor, 1997). One such danger could be re-injury. Re-injury is an inherent risk when returning to play after ACL injury. Experiencing an ACL tear is associated with an increased risk of a subsequent ipsilateral or contralateral ACL tear as well as meniscal damage post-surgery and rehabilitation (Walden, 2013). Fear of re-injury can limit athletes' functional abilities and ultimately ability to return to play. Some degree of avoidance of physical activity during rehabilitation can aid in recovery; however, continued avoidance can lead to decreased function and limitations in returning to sport (Heil, 1993; Kori et al., 1990; Tripp et al., 2007).

Although typically used in describing and predicting chronic pain, Roos (2010) and Chmielewski et al. (2008) both argue that the use of a fear-avoidance paradigm (Waddell, Wallston, Kaplan, & Maides, 1976) may also be appropriate for use with patients after ACL reconstruction surgery. Specifically, Roos notes that the premise of a fear-avoidance model for use with athletes post-ACL reconstruction surgery is that athletes with a history of ACL reconstruction may be fearful of performing behaviors (e.g., returning to play) that could put them at risk for painful re-injury and thus they avoid these potentially dangerous situations (Waddell et al., 1976). Therefore, athletes with a higher level of fear of re-injury will less likely to return to play as compared to athletes with lower levels of fear of re-injury.

When testing the relationship between fear avoidance beliefs and return to play after ACL reconstruction surgery, Roos (2010) surveyed athletes at approximately 2.5 years post-ACL reconstruction surgery. They found that high fear-avoidance beliefs at 2.5 years post-ACL reconstruction surgery were significantly associated with decreased perceived knee function, decreased perceived ability to perform activities of daily living, and decreased perceived ability to perform sport and physical activity related skills.

Kvist et al. (2005) found further support for the relationship between fear of re-injury and return to play after ACL reconstruction surgery. In their examination of fear of re-injury and return to play, Kvist et al. acknowledged a low rate of return to play, with only 53% of participants having returned to play 3-4 years post-surgery. The authors found that those athletes who had not returned to play scored significantly higher on measures of fear of re-injury than athletes who had returned to play. Moreover, 24% of participants who had not returned to play explicitly cited fear of re-injury as the reason for their discontinuation, although they did not provide further explanation of why they were fearful of re-injury or if they were having other physical or psychological symptoms related to this anxiety.

McCullough et al. (2012) examined male high school and collegiate football players with regard to return to play post-ACL injuries, as well as attributions for not returning to play and self-reported performance upon return to play attempts. These researchers found that although 63% of high school athletes and 69% of collegiate athletes had returned to play by the 2-year follow-up, only 45% of high school players and 38% of college athletes had returned to football at their self-reported previous level of performance. Fear of re-injury, along with competing interests, were the most

commonly cited reasons for not returning to play, whereas the least commonly cited reasons were physical symptoms, being advised not to return to play, and loss of speed or strength. Participants did not indicate perceived reasons for decrease in performance.

Chmielewski et al. (2008) reported similar findings with respect to the relationship between fear of movement/re-injury, physical function, and pain in patients recovering from ACL surgery. They found that fear of movement/re-injury decreased throughout the rehabilitation process and that fear of re-injury was negatively associated with physical function based on medical records. The time since surgery, however, may have been a confounding factor in this relationship. Higher pain levels were also associated with lower function, although time since surgery may have mediated this relationship. Based on the results of this study, however, we cannot determine if fear of re-injury is the cause of increase pain or if increased pain was the cause of fear of re-injury.

Ardern, Taylor, Feller, Whitehead, and Webster (2013b) also identified psychological responses as being important in return to play following ACL reconstruction. They conducted a prospective study to determine if psychological responses pre-surgery and at 4 months post-operatively would predict return to play at 12 months following ACL reconstruction surgery. At 12 months post-operatively they found that 31% of athletes had returned to their pre-injury sport at the same level. They again found that fear of re-injury, along with other psychological predictors (assessed at 4 months post-surgery), was associated with return to play at 12 months post-surgery. Specifically, higher psychological readiness to return to play, lower fear of re-injury, more internal sport rehabilitation locus of control, and lower number of months athlete's

predicted it would take for them to return to play were predictive of an athlete returning to play at 12 months.

Tjong, Murnaghan, Nyhof-Young, and Ogilvie-Harris (2014) conducted a qualitative study to determine athletes' self-reported attributions for not returning to sport after ACL reconstruction surgery. They conducted semi-structured interviews with 31 male and female athletes who had undergone ACL reconstruction surgery. Of the 31 participants in this study, 20 had not returned to their pre-surgery level of sport at the time of interview – at least 2 years post-surgery. Fear of re-injury again was identified as an important contributor to why athletes did not return to play following ACL reconstruction. They found three distinct patient-derived themes related to why athletes did not return to play: fear, priorities, and personality. The fear identified by participants in this study included fear of re-injury, pain, being a financial burden, the sport itself, or disablement. Although fear was the most common theme identified by Tjong et al. (2014) in their qualitative analysis of attributions for not returning to sport after ACL reconstruction, two other distinct themes related to attributions for not returning to sport emerged – priorities and self-perceived personality traits. Specifically, participants who had not returned to sport had identified changes in priorities as being a contributor to this decision, whereas those who had returned identified sport being a high priority as one of the reasons they decided to return. Within the final theme – personality traits – athletes who had not returned to sport indicated they were cautious, relaxed, tended to procrastinate, and lacked self-confidence. In contrast, those athletes who had returned to sport indicated they were "self-motivated, competitive, team oriented, and self-aware" (Tjong et al., 2014, p. 4) which contributed to their success in returning to sport.

Cupal and Brewer (2001) tried to improve return to play outcomes and employed one of the few randomized controlled trial designed studies in this area with male and female competitive and recreational athletes aged 18 to 50 after ACL reconstruction. Participants in the treatment group participated in 10 sessions of relaxation and guided imagery on top of their typical physical therapy treatment. The authors found that the use of relaxation and guided imagery with athletes recovering from ACL injury significantly improved knee strength scores in the treatment group as compared to the control and placebo. Moreover, this intervention significantly reduced pain and re-injury anxiety. The authors suggest that the beneficial effect of the intervention on knee strength may be due to the reduction in fear of re-injury found in the treatment group. In summary, fear of re-injury appears to be associated with return to play outcome when assessed at 3-4 years post-surgery (Kvist et al., 2005), 2 years post-surgery (McCullough et al., 2012; Roos, 2010) and 4 months post-surgery (Ardern et al., 2013b).

Mood disturbance and mental health. In addition to fear of re-injury another affective response that has been found to influence athletes in returning to play after ACL injury is mood disturbance or mental health. Athletes who suffer injury have been found to be at risk for mood disturbance or even clinically diagnosable psychopathology throughout their recovery (Appaneal, Levine, Perna, & Roh; 2009; Smith, Scott, & Wiese, 1990). This risk for mood or mental health problems post-injury is concerning in and of itself, however, it also has potential implications for rehabilitation outcomes including return to play.

Tripp and colleagues (2007) examined negative affect, fear of re-injury, and pain catastrophizing as predictors of return to play and sport confidence in male and female

adult recreational athletes who had suffered ACL injuries. These authors found that psychological responses accounted for significant variance in athletes' confidence in returning to sport. Once the authors controlled for the effects of current physical activity level and education, however, only negative affect was significantly associated with confidence in ability to participate in sport. Athletes who were higher in negative affect reported report lower levels of confidence in their ability to participate in sport. Fear of re-injury was the lone predictor of returning to sport, with participants higher in fear of re-injury being less likely to return to play.

Langford and colleagues (2009) also found psychological responses to be important in athletes' likelihood of returning to play. These researchers hypothesized that athletes with lower mood disturbance would be more likely to return to play 12 months post-operatively. They found partial support for this hypothesis. Athletes with lower mood disturbance at 12 months were not significantly more likely to have returned to sport. Those athletes; however, who felt more positively about return to play, assessed with the ACL Return to Sport After Injury Scale (ACL-RSI), were significantly more likely to have returned to play at 12 months follow up. This included their emotions and risk appraisal associated with return to play and fear of re-injury at 6 and 12 months. Overall, mood state has been found to be associated with return to play in athletes with ACL injuries; however, comparatively it has received less attention than other psychological factors (e.g., fear of re-injury, and self-efficacy).

Behavioral responses. Efforts, actions, and activities post-injury are considered behavioral responses to sport injuries. With specific attention to ACL injuries, te Wierike

et al. (2013) identified adherence and coping as important behavioral responses associated with ACL rehabilitation outcomes.

Adherence. In addition to cognitive and affective factors, behavioral factors also are predicted to influence the outcomes of sport-related injuries (Brewer et al., 2000, 2004; Wiese-Bjornstal et al., 1998). One of the key behavioral factors found to be associated with both cognitive and affective responding to injury, as well as rehabilitation outcomes, is adherence to rehabilitation programs (Brewer et al., 2000, 2004). Brewer and colleagues (2004) assessed the relationship between adherence and recovery outcomes in patients following ACL reconstruction surgery. The authors found a significant relationship between self-reported knee outcomes 6 months post-operatively and adherence to rehabilitation programs. Specifically, those participants who attended a higher percentage of their rehabilitation sessions, were rated by their health care professionals as giving greater efforts in rehabilitation and following instructions better, and who were more receptive to changes in rehabilitation protocol had fewer self-reported negative knee symptoms at 6 months post-surgery.

In a review of 10 studies that investigated the relation between psychosocial factors, treatment adherence, and outcomes of rehabilitation post-ACL injury and/or surgery, Mendonza, Patel, and Bassett (2007) found a consistent relationship between psychosocial factors and physical outcomes, with rehabilitation adherence playing a mediating role. Specifically, it was found that "motivation, a sense of personal control, social support, self-efficacy, and fear of re-injury" (Mendonza et al., 2007, p. 70) all influenced adherence to rehabilitation, and indirectly rehabilitation outcomes.

The aforementioned research highlights that the psychological responses to sport injury affect both psychological and physical recovery from injury. Affective, cognitive, and behavioral factors have proven important in predicting athletes' success in returning to play after injuries. At times, research have found psychological responses to be more important than physical variables in determining if an athlete will return to play or not post-ACL reconstruction surgery (Kvist et al., 2005; Langford et al., 2009). This is consistent with Wiese-Bjornstal et al.'s (1998) integrated model, which highlights the connection between psychological responses and rehabilitation outcomes among athletes recovering from injuries. By understanding the negative cognitive, emotional, and behavioral responses, we can better understand which psychological responses may inhibit successful return to play and ultimately what it means to be psychologically ready to return to play after ACL injuries. There currently exists no standard definition for psychological readiness to return to play after ACL injuries. In light of recent and established research findings, however, it is clear that psychological readiness to return to play following ACL surgery is a multidimensional construct. It involves several cognitive (i.e., high self-efficacy, greater perceived recovery), affective (i.e., lower mood disturbance, lower fear of re-injury), and behavioral factors (i.e., higher rehabilitation adherence) (see te Wierike et al., 2013 for review).

Summary of Research

Despite strong theoretical and empirical evidence on the relationship between psychological responses and recovery outcomes in athletes with ACL injuries there are still a number of limitations to the current literature. Specifically, the literature is limited in three key ways. First, there have been few longitudinal studies examining changes in

psychological responses across the duration of ACL rehabilitation. Much of the research has been cross-sectional (Chmielewski et al., 2008) or retrospective (Kvist et al., 2005; Podlog & Eklund, 2006; Tjong et al., 2014; Tripp et al., 2007) rather than repeated in design. The research that has examined the relationship between psychological responses and rehabilitation outcomes longitudinally has primarily focused on the relationship between psychological responses early in rehabilitation, between 6-weeks and 4-months post-surgery (Ardern et al., 2013b; Brewer et al., 2007; LaMott, 1994), and rehabilitation outcomes. The typical course of ACL rehabilitation can extend from 9- to 12-months post-surgery. Thus, by only examining the psychological responses early in rehabilitation we miss capturing psychological responses during the latter part of rehabilitation including the period of return to play. This is especially important considering return to play has been found to be a period associated with increased stress and anxiety (Podlog & Eklund, 2005, 2006).

The second limitation of the previous research on psychological responses and rehabilitation outcomes after ACL reconstruction surgery is the measurement of psychological responses. First, psychological responses have often been studied in isolation rather than examining multiple psychological responses in the same study (Chmielewski et al., 2008; Kvist et al., 2005; Langford et al., 2009; Thomeé et al., 2007, 2008, 2010). By examining only one psychological construct at a time, researchers are limited in their ability to judge the relative importance of specific psychological responses as correlates of rehabilitation outcomes. Second, much of the previous research has used general population measures of psychological constructs rather than measures developed specifically for a sport population (Chmielewski et al., 2008; Tripp

et al., 2007). By using general population measures researchers may be missing experiences or responses that are unique to athlete populations. For example, the Tampa Scale of Kinesiophobia (TSK; Kori et al., 1990) has been used for research examining fear of re-injury in athletes post-ACL reconstruction, yet it was developed for use on a non-athlete population, specifically, people with low back pain. Items on this inventory focus on exercising and general movement and thus may not capture the extensive physical demands of competitive sport as compared to a sport specific measure like the Re-Injury Anxiety Inventory (RIAI; Walker et al., 2010). By using sport-specific measures, we can get a more accurate and complete picture of the psychological responses to ACL injuries in athletes.

The third limitation of previous research is that return to play has been examined as an isolated dichotomous variable – athletes either return or did not return to play (Ardern et al., 2013b; Langford et al., 2009; Tripp et al., 2007). Researchers have argued that return to play falls into a broader context of overall disablement meaning that return to play influences and is influenced by impairments, functional limitations, and quality of life (Vela & Denegar, 2010a, 2010b). By examining return to play more broadly we can better understand this important rehabilitation outcome beyond a yes, no response.

Purposes of the Present Study

Based on these aforementioned limitations as well as theory and past research, the study purposes were twofold. The first purpose of this study was to determine if there were differences between athletes who returned to play after ACL reconstruction surgery and those who did not return to play after ACL reconstruction surgery in terms of psychological responses to injury over the latter part of rehabilitation. The second

purpose of this study was to determine if psychological responses to injury at 4- and 6-months post-ACL reconstruction surgery would predict perceptions of disablement at 9-months post-surgery as an outcome of ACL rehabilitation.

To achieve these purposes, two research questions were designed to address purpose one (research question 1 and research question 2) and one research question was designed to address purpose two (research question 3). These are as follows.

1. Do psychological responses to injury (i.e. knee self-efficacy, re-injury anxiety, mental health) differ in participants who return to play and those who do not return to play at 4-, 6-, and 9 months post-surgery?
2. Do perceptions of recovery (i.e., perceived limitations to ability, and perceived percent recovery) differ in participants who return to play and those who do not return to play at 4-, 6-, and 9 months post-surgery?
3. Do psychological responses to injury at 4- and 6-months predict perceived disablement at 9 months post-surgery?

CHAPTER 2

Method

Participants

Thirty-two participants (15 male, 17 female) were recruited from a large orthopaedic medicine center for this study. One-hundred and eighteen participants were initially contacted for the study. Of these, 37 could not be reached, 25 did not return informed consent forms, 11 did not meet inclusion criteria, 1 did not complete any questionnaires, and 10 did not have 9-month follow up data. This resulted in a final sample of 32 participants (see Figure 3). Participants ranged in age from 13 to 58 years with a mean age of 27.22 years (*SD*=11.39). Seventeen (53.1%) participants self-identified as competitive athletes and 15 (46.9%) as recreational athletes. All participants met the following inclusion criteria in preliminary screening: (a) they had undergone surgical repair for an ACL tear, (b) this was their first ACL tear, (c) they were between the ages of 13 and 64 years, and (d) they were active in sport or physical activity prior to the injury and intended to return to play or physical activity after their rehabilitation from ACL reconstruction surgery (e) they were under-going standard ACL rehabilitation protocol (i.e., they had no additional injuries that would require a longer time on crutches or a different rehabilitation protocol).

For further analysis participants were divided into those who had returned to play at 9-months and those who had not. All non-returners indicated that the reason they had not return to sport was related to their injury. Some indicated that it was because of specific physical symptoms (e.g., “the knee is still unstable), while others noted functional deficits (e.g., “I’m practicing but not as quick or explosive enough to play.

Still others indicated that the reason they had not returned to play was because of psychological responses (e.g., I am nervous to return fully so I've been procrastinating).

Returners included eight males and 10 females; 12 of whom self-identified as competitive athletes, while six identified as recreational athletes. By comparison, non-returners included seven males and seven females, with five self-identified competitive athletes and 9 recreational athletes. Returners were significantly younger (M_{age}=23.28, *SD*= 9.57) than non-returners (M_{age}=32.29, *SD*=11.85) $t(30)=-2.38$, $p<.05$. There also was a trend towards more competitive athletes in the returners group; however, this trend did not attain significance χ^2 (1, N=32) = 3.03, $p=.08$. There also was no difference between groups on self-reported level of adherence at any time point between groups – 4-months post-surgery $t(30)=1.97$, p=.12, 6-months post-surgery $t(28)=.37$, $p=.60$, and 9-months post-surgery $t(30)= .44$, $p=.37$. See Table 1 for a summary of the descriptive statistics for the two groups. Participants in the "returners" and "non-returners" groups identified a variety of sports which they considered to be their most important sports. These sports included both team and individual sports, contact and non-contact sports. Table 2 displays the number of participants in each group who self-identified each sport as their most important sport. A complete summary of participants' age, gender, sport, competitive level, and return status is available in Appendix A.

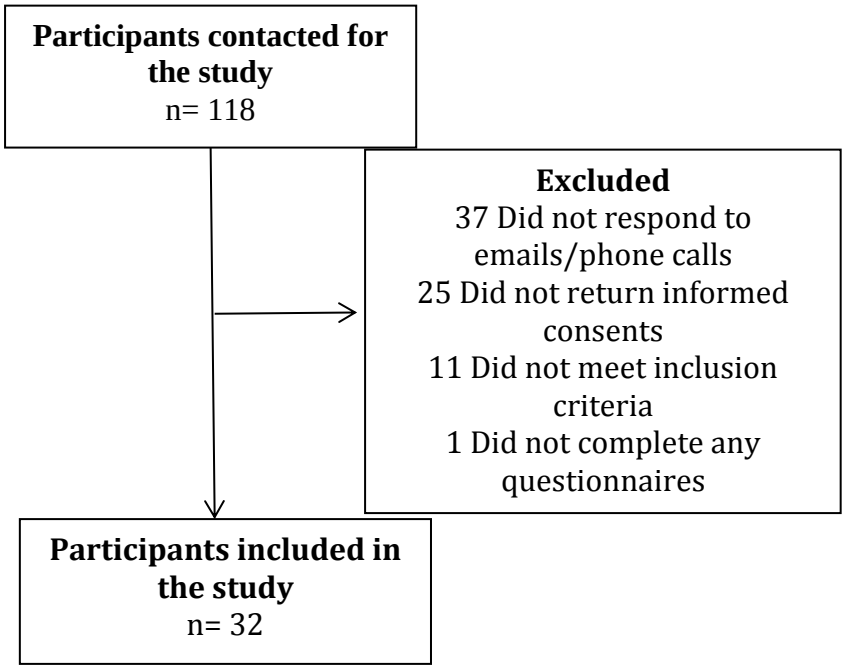

Figure 3. Summary of participants contacted for this study.

Table 1

Descriptive Statistics of Returners and Non-Returners

				Gender		Competitive Level	
	N	Age (years)	SD	M	F	C	R
Returners	18	23.28	9.57	8	10	12	6
Non-Returners	14	32.29	11.85	7	7	5	9

Note. F=female, M=male, C=Competitive sport, R=Recreational sport

Table 2

Most Important Sports of Returners and Non-Returners

Returners	N	Non-returners	N
Basketball	4	Baseball	1
Downhill skiing	1	Basketball	1
Football	4	Biking	1
Hockey	1	Golf	1
Lacrosse	2	Karate	1
Running	1	Motocross	1
Soccer	1	Running	2
Softball	2	Skiing	1
TaeKwonDo	1	Soccer	1
Running	1	Swimming	1
		Tennis	1
		Ultimate	1
		Volleyball	1

Measures

Measures were selected based on a comprehensive review of literature with special attention to the recent review paper completed by te Wierike et al. (2013). In the interest of reducing the demands on participants' time, only the psychological responses with the most theoretical and research support identified by te Wierike et al. (2013) and other literature reviews were utilized in this study. Figure 4 displays the psychological responses (cognitions, affects, and behaviors) variables assessed in the present study. Outcome variables were also derived from a comprehensive review of literature. I will further explain all variables and measures in the following section. The measures are available in the order they were completed by participants in Appendix B. A summary of

all psychological and outcome constructs as well as definitions of the construct and questionnaires used the measure each construct is available in Table 3.

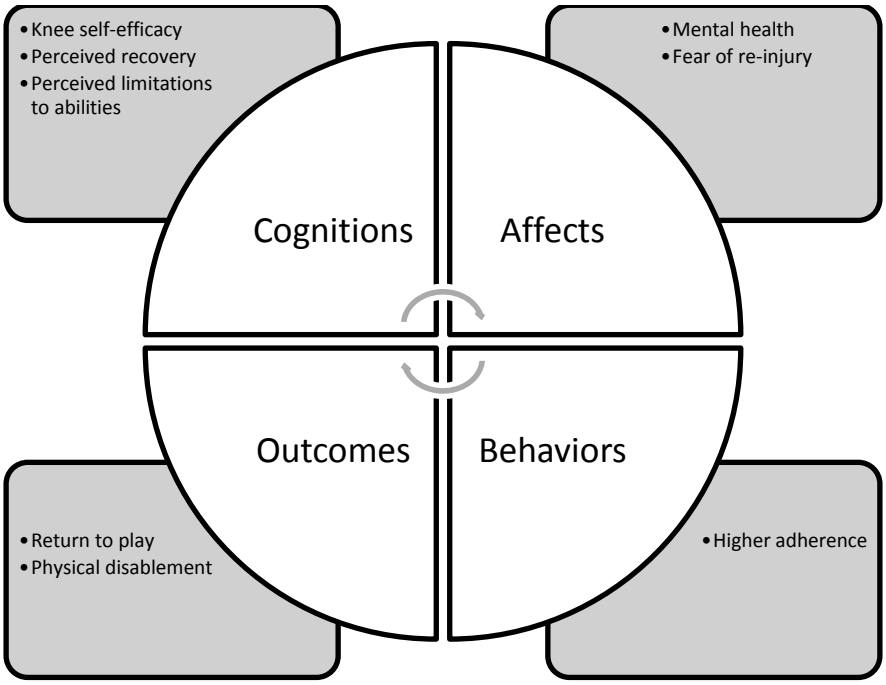

Figure 4. Model summarizes the review of literature on psychological response associated with return to play after ACL injuries conducted by te Weirike et al. (2012). Adapted from "Psychology and Socioculture Affect Injury Risk, Response, and Recovery in High-Intensity Athletes: A Consensus Statement." by D. M. Wiese-Bjornstal, 2010, *Scandinavian Journal of Medicine & Science in Sports, 20*, p. 106. Copyright 2010 by John Wiley and Sons.

Table 3

Psychological Constructs, Operational Definitions, and Measures used to Assess the Constructs

Construct	Operational Definitions	Measure
Cognitions	Interpretations, appraisals, and beliefs experienced post-injury (Wiese-Bjornstal, 2010).	
Knee self-efficacy	Perceived ability of knee to perform the tasks necessary to participate in sport or physical activity (Thomeé et al., 2007).	Knee Self-Efficacy Scale (K-SES: Thomeé, 2003, 2006)
Perceived recovery	Perception of progress towards full recovery.	Item from Emotional Response of Athletes to Injury Questionnaire(ERAIQ; Smith et al., 1990)
Perceived limitations to abilities	Perception of limitations to the ability to do the activities associated with participation in their sport.	Item from Activities Scale (Agel, 2013)
Affects	Emotions, feelings, and moods experienced post-injury (Wiese-Bjornstal, 2010).	
Fear of re-injury	Future oriented worry about experiencing another knee injury	Re-Injury Anxiety Inventory (RIAI; Walker et al., 2010)
Mental health	Psychological and emotional well-being, for the purposes of this project specifically focusing on levels depression and anxiety.	Patient Health Questionnaire (PHQ-4; Kroenke et al., 2009)
Behaviors	Efforts, actions, and activities engaged in post-injury (Wiese-Bjornstal, 2010)	
Adherence	Degree to which a patient 'sticks' to their rehabilitation program	Patient Self-Report Scales of Their Home-Based Rehabilitation Adherence (Basset et al., 2003)

Outcomes		
Return to play	"Medical clearance of athletes for full participation in sport without restriction (strength and conditioning, practice and competition)" (Creighton et al., 2010, p. 380)	Research developed item asking if participants had returned to play & item from Activities Scale (Agel, 2013)
Disablement	"The sequence of interrelated but discrete events that take place as a result of pathology, and ultimately leads to disability or participation restriction" (Denegar et al., 2008, p. 340).	Disablement in the Physically Activity Scale (Vela & Denegar, 2010a)

Cognitive Measures. Cognitive appraisal factors include interpretations, appraisals and beliefs athletes experience after ACL injury and surgery (Wiese-Bjornstal, 2010).

Knee Self-efficacy. The Knee Self-Efficacy Scale (K-SES; Thomeé, 2003; Thomeé et al., 2006) was used to assess participant knee self-efficacy. This inventory was selected because of its good psychometric properties and because it is intended for use specifically with athletes with knee injuries. The K-SES is a 22 item self-administered questionnaire that asks participants to rate how certain they are they can perform specific activities including activities of daily living, physical activities, sport and leisure activities and their expectations of knee function in the future. Specifically, the stem for each question is "mark the number that best represents how certain you are about the activity right now despite pain/discomfort." A sample item is: "how certain are you that you can participate on the same activity level as before your injury"? All items are scored on a 0-10 Likert scale, 0 indicated *not at all* and 10 indicated *certain.* A higher score on this inventory indicates higher knee self-efficacy. This measure was validated with an active population aged 16 to 60 who had a history of ACL injuries. The authors note that this measure has good content validity as it was developed and modified by a panel of sports medicine and sport psychology experts. The authors found that the test re-test reliability was good ($r = 0.73$). Additionally, the internal consistency was 0.94 indicating acceptability. The K-SES has four subscales. For the purpose of the present study, only two of the subscales – physical activities, and knee function in the future were used as other subscales were less relevant at the time points selected post-

surgery as all participants should be able to complete the activities of daily living at that time point.

Perceived recovery. One item from the Emotional Responses of Athletes to Injury Questionnaire (ERAIQ; Smith, Scott, O'Fallon, & Young, 1990) was used to assess perceived percent of recovery. The ERAIQ was developed by Smith et al. (1990) to assess athletes' psychological responses to injury. The single item used in this study asked participants to self-report on a scale of 0% to 100%, in increments of 10, what percent of recovery they thought they had achieved. It is high in face validity as a direct measure of perceived recovery.

Perceived limitations to ability. The Activities Scale was developed by Agel (2013) to assess participants' physical activity level post-injury. Participants are asked to report their favorite and second favorite activity, as well as the frequency and duration of participation in that sport or activity prior to injury and currently. For the purpose of this study, only two items were used. In order to assess perceived limitations to ability a single item that asked participants to indicate on a scale of 0 to 10 how much their ability to participate in sport or physical activity is limited by their injury was utilized. This scale has not yet been tested on psychometric properties.

Affective meaures Affective responses include emotions, feelings, and moods athletes experience after an ACL injury and surgery (Wiese-Bjornstal, 2010).

Fear of re-injury. Re-Injury Anxiety Inventory (RIAI) developed by Walker and colleagues (2010) was used to measure fear of re-injury. This measure was selected because of its sound psychometric properties and because it was developed specifically

for use with injured athletes. The stem of the questions is as follows: "Below are several statements that athletes have used to describe their feelings regarding re-injuries worries. Read each statement and circle the appropriate number to indicate how you feel right now, at this moment." (Walker et al., 2010, p. 27). An example item is "I am worried about re-entry into competition making my body feel tense." All items are on a 4-point Likert scale with answers ranging from *not at all* to *very much so*. A higher score on the RIAI is indicative of higher re-injury anxiety. This measure was validated with male and female athletes aged 17 to 39 who were injured while participating in sport. The authors indicated that there is good content validity for the RIAI as it was reviewed multiple times by a panel of sport psychology experts. The internal consistency was also found to be good – re-injury anxiety surrounding rehabilitation (alpha = .98), re-injury anxiety surrounding return to play (alpha = - .96). This measure has two subscales – rehabilitation and return to play. For the purpose of this study only the return to play subscale was used because the purpose of this study was specifically to examine experiences and affect related to return to play.

Mental health. Mental health, specifically depression and anxiety, was measured using the Patient Health Questionnaire- 4 (PHQ-4; Kroenke, Spitzer, Williams, & Löwe, 2009). This measure was selected based on its strong psychometric properties and because it is easy to administer in a health care setting due to its clear instructions and limited questions. This inventory is a diagnostic tool designed to be able to screen mental health with a brief and easy questionnaire. The PHQ-4 is a 4-item inventory that combines the PHQ-2 (Kroenke et al., 2009) a 2-item inventory used to assess depression

and the GAD-2 (Kroenke et al., 2009) a 2-item inventory used to assess anxiety. When completing this tool, participants indicate on a scale of 0 to 3 how often symptoms of depression and anxiety have bothered them in the last 2 weeks. A sample item on this inventory is "Not being able to stop or control worrying." A higher score indicates a higher degree of psychological distress. When using this tool in clinical practice a cumulative score of 3 or higher indicates that the patient requires additional psychological evaluation. This scale has been validated in a general population of both males and female aged 14 to 75 (Kroenke et al., 2009). The PHQ-4 has been found to have good construct validity showing strong correlations with other well-established inventories assessing anxiety and depression. Authors report the internal reliability was good (alpha= >.80). Factorial validity was also good with 84% of the variance explained by the two factors of depression and anxiety. This measure has been deemed appropriate for use as a short screening for anxiety and depression showing a strong correlation (r=.88) with the longer version the PHQ-9 (Kroenke, et al., 2009).

Behavioral measures. Behavioral responses are efforts, actions, and activities that athletes engage in following ACL injury and surgery (Wiese-Bjornstal, 2010).

Rehabilitation Adherence. Adherence was assessed with a measure developed by Bassett (2003). Specifically, Bassett's Patient Self-Report Scale of Their Home-Based Rehabilitation Adherence questionnaire is a three item measure that asked participants to rate on a 5-point Likert scale how well they adhered to the physical therapist's instructions with 1= not at all and 5 = as advised. The instructions for the items: "For each of the treatment methods you have been requested by your physical

therapist to do at home please indicate the words and numbers that best indicate the extent you have followed the instructions about doing this form of treatment." For the purpose of this study, only two of the three questions were used – "Exercises" and "Refraining from undertaking the sporting and daily activities that the rehabilitation personnel advised not to do" (Bassett, 2003, p. 63) as the "application of ice" (p. 63) question was not deemed relevant at the time points assessed in this study. This measure has not been previously tested for psychometric properties. Our intention was to also collect rehabilitation adherence data from health care professionals as a second measure of rehabilitation adherence. After reviewing patient charts; however, it was determined that the necessary data was not available; therefore, adherence was excluded from data analyses.

Outcome measures. As described in Vela and Denegar's (2010a) model of disablement, return to play fits within the larger context of this disablement paradigm. Therefore, in this study, we assessed the overall construct of disablement as an outcome variable for athletes recovering from ACL injuries and also focused specifically on the return to play component, as it is often the most important outcome for athletes.

Perceived physical disablement. Perceived physical disablement was assessed using the Disablement in the Physically Active Scale (DPA; Vela & Denegar, 2010a, 2010b). The DPA is a multidimensional assessment based on the physical disablement model developed by and Vela and Denegar (2010a). This scale assesses perceived disablement across four domains – impairments, functional limitations, impairments, and health related quality of life. This is a 16-item scale where participants rate on a scale of

1 to 5 (where 1 indicates that patient has no problem with the listed item and 5 indicates the person is severely impacted by the listed item) how much of a problem symptoms of disablement are for them. A sample item is "Do I have impacted muscle function? Ex. Decreased range/ease of motion, flexibility, and/or increase stiffness." Scores on this inventory range from 16 to 80 with a higher score indicating higher perceived physical disablement. This scale has been validated with active males and females with musculoskeletal injuries with a mean age of 20.1 years (*SD*=3.8). This scale has been found to have good reliability (alpha = .91) and validity showing an inverse relationship with global functioning as well as good responsiveness.

Return to play. Return to play was determined using a single item, author-developed question whereby participants were asked to indicate if they had or had not returned to their pre-injury level of sport or physical activity. This item was followed up by a question from Agel's (2013) Activity Scale asking participants who indicated they had not returned to their previous level of activity, why they had not. On this item, participants indicated one of two options as to why they had not returned to their favorite sport or physical activity post-surgery due to injury related symptoms or other. The "other" question then gave participants the opportunity to explain further their reason(s) for not returning to their favorite sport of physical activity at that time. The data from these two questions was used to group participants as either "returners" (meaning that had returned to sport at 9-months post-surgery) or "non-returners" (they had not returned to sport at 9-months post-surgery). All participants were grouped based on their response to the yes or no question asking if they had or had not returned to sport and then group

membership was confirmed and explained using the follow-up question from Agel's (2013) Activity Scale.

Demographics. Athletes also completed a demographic questionnaire that included their age, competitive level, current injury, surgery date, mechanism of injury, sport they intend to return to playing, and estimated return to play date. Age data was used to confirm their eligibility for the study and to assess potential demographic differences between "returners" and "non-returners." Competitive level was assessed using a multiple choice item where participants could indicate if they self-identified as being recreational athletes, junior high or high school athletes, club athletes, national level athletes or competitive athletes. This was then used to assess differences in competitive level between "returners" and "non-returners." Surgery date data was used to determine when participants would be sent questionnaires. Mechanism of injury data was used to determine if participants had been injured in sport. Intention to return to play was used to confirm the inclusion criterion of an intention to return to play. Estimated return to play data was used to assess participants' expectations of how long it would take to return to play after ACL reconstruction surgery.

Procedure

IRB approval was attained from the university's Institutional Review Board (IRB; see Appendix C). Prior to data collection, all measures were given to children ages 12-14 years to assess readability and time demands in completing questionnaires. Through professional connections with members of the research team for the larger project, TRIA Orthopaedic Center was identified as a location for recruitment for this study and

approval was obtained from TRIA to recruit from their clinic. TRIA is a comprehensive orthopaedic center that provides orthopaedic care including diagnosis, treatment (including surgery), and rehabilitation at one location. TRIA employs a number of othopaedic surgeons and physical therapists specializing in the surgical treatment and rehabilitation of patients after ACL tears; therefore, participants in this study received treatment and care from a variety of health care professionals (TRIA, 2014).

TRIA research staff identified potential participants for this study from individuals who had undergone ACL reconstruction surgery at TRIA. Potential participants were provided with an informational letter (either in person or via mail) about this study (see Appendix D). In this letter the study was described and participants (or parents of participants if under 18 years of age) were asked to provide contact information if they were interested in participating in the study. Potential participants were then contacted by phone or email, based on their preference. During this communication, potential participants were asked preliminary screening questions (Appendix E) to determine their eligibility for the study. This included asking participants' birth dates, their intention to return to sport or physical activity after rehabilitation, and if they had had previous ACL injuries. Informed consent forms (Appendix F for adults) were sent to participants who met inclusion criteria and who were still willing to participate in the study. If participants were under 18 they were mailed a parental consent form (Appendix G), HIPPA authorization form, and an assent form (Appendix I). All participants were sent a HIPPA authorization form (Appendix H).

Questionnaires were administered a 4-, 6-, and 9-months post-ACL reconstruction surgery using Qualtrics software, of the Qualtrics Research Suite. Copyright © [2014] (Qualtrics, Provo, UT). Qualtrics is a secure online survey tool. At each time point, a Qualtrics survey online link was emailed to each participant 5 days prior to each time point of assessment (e.g., if a participant's surgery date was January 1 her or his questionnaire was emailed 5 days prior to 4-months post-surgery – April 26). If participants did not complete the questionnaire within one week, they received a reminder email with the survey link. This link was then disabled one week after a follow-up reminder. Participants received a gift card via mail when they completed each of the questionnaires ($10 at 4 and 6 months post-surgery and $20 at 9-months if they had completed all the questionnaires). At 4-, 6-, and 9-months post-surgery all psychological and outcome measures were completed by participants with the exception of the Disablement in Physical Activity Scale, which was only completed at 9-months post-operatively. A complete list of measures completed by participants is available in Table 4.

Table 4

Measures at Each Time Point

	4-months post-surgery	6-months post-surgery	9-months post-surgery
Demographics	Demographic questionnaire		
Cognitions	Knee Self-Efficacy Scale (2 subscales) Emotional Responses of Athletes to Injury Questionnaire (1 item) Activity Scale (1 item)	Knee Self-Efficacy Scale (2 subscales) Emotional Responses of Athletes to Injury Questionnaire (1 item) Activity Scale (1 item)	Knee Self-Efficacy Scale (2 subscales) Emotional Responses of Athletes to Injury Questionnaire (1 item) Activity Scale (1 item)
Affects	Patient Health Questionnaire - 4 Re-injury Anxiety Inventory (1 subscale)	Patient Health Questionnaire Re-injury Anxiety Inventory (1 subscale)	Patient Health Questionnaire Re-injury Anxiety Inventory (1 subscale)
Behaviors	Adherence Scale (2 items)	Adherence Scale (2 items)	Adherence Scale (2 items)
Outcomes	Activity Scale (2 items) Return to Play Item	Activity Scale (2 items) Return to Play Item	Activity Scale (2 items) Return to Play Item Disablement in the Physical Active Scale

Design and Data Analyses

This study was part of a larger study examining the role of psychological responses in recovery from injury as well as validating a new measure of psychological responses to sport injury. For purposes of this project, psychological responses most relevant to the research questions were assessed. This study employed a repeated measures design. Participants were asked to complete a series of questionnaires at 4-, 6- and 9-months post-ACL reconstruction surgery in order to encompass the return to play period. These time points were selected to correspond with important time points in ACL rehabilitation protocol. Specifically, by 4-months post-surgery issues with range of motion, pain, and swelling should be resolved. At this point, athletes can typically begin some light jogging and increase gradually to more sport specific training. Six-months post-surgery is considered to be the early end of the return to unrestricted activity time frame where athletes may be able to return to sport if they meet required physical outcomes. By 9-months post-surgery most athletes are expected to meet the physical requirements of returning to unrestricted activity (Delay et al, 2000; Heijne et al., 2008; Stoehr et al., 2014).

Portions of this study employed a mixed model design. The between-subjects factor included return status at 9-months (returned, did not return) and the within-subjects factor was time of assessment (4-, 6-, 9-months). Participants completed measures of psychological responses at each time of assessment and outcomes measures of perceived disablement and return to play at 9-months post-surgery. This design allowed for

examining differences between returners and non-returners at various points in the rehabilitation process.

Statistical analyses were conducted using SPSS 20.0 (IBM Corp, Armonk, New York). Descriptive statistics (means, standard deviations, correlations) were calculated for all demographic, psychological, and return to play variables. Internal consistency reliability was determined using Cronbach's alpha for all multi-item variables at each of the three assessment periods. I used harmonic mean substitution for participants with only one missing item. Four participants failed to complete any questionnaires at 1 or more time points and therefore had to be excluded from analyses. Thus, only 29 of the 32 participants had complete data and were used for subsequent analyses.

Research question 1. I conducted a 2 (Return Status) by 3 (Time) repeated measures multivariate analysis of variance (RM MANOVA) to address research question 1. Dependent variables included knee self-efficacy, re-injury anxiety, and mental health. Effect size was determined using Cohen's *d* with values .20 being weak, .50 being moderate, and .80 being strong (Cohen, 1992).

Research question 2. I conducted a 2 (Return Status) by 3 (Time) repeated measures multivariate analysis of variance (RM MANOVA) to address research question 1. Dependent variables included perceived percent recovery and perceived limitations to ability. Effect size was determined using Cohen's *d* with values .20 being weak, .50 being moderate, and .80 being strong (Cohen, 1992).

Research question 3. To address research question 3 I ran two stepwise multiple regression analyses to determine if psychological variables at 4- and 6- months predict

perceived disablement at 9 months. Age was entered at the first step and the set of psychological response scores was entered at the second step. This approach enabled determination of collective and unique variance explained in perceived disablement. Effect size was determined by the overall and unique variance explained in perceived disablement.

CHAPTER 3

Results

Scale Reliabilities

All multi-item scales achieved adequate internal reliability using Cronbach's alpha coefficients at 4-, 6-, and 9-months post-surgery (see Tables 5, 6, and 7). I also conducted bivariate correlations between all dependent variables to assess multicollinearity. Variables showed some degree of correlation but not so high as to indicate multicollinearity and preclude use of MANOVA .

Table 5

Bivariate Correlations and Alpha Reliabilities for 4-months Post-Surgery

Variable	1	2	3	4	5
1. RIAI	.88				
2. K-SES	-.17	.70			
3. PHQ	.47	.00	.69		
4. Ability	.38	-.30	.25	-	
5. % Recovery	-.22	.28	.09	-.52*	-

Notes: RIAI = Re-injury Anxiety Inventory (Walker et al., 2010); K-SES = Knee Self-Efficacy Scale (Thomeé et al., 2003, 2006); PHQ = Patient Health Questionnaire-4 (Kroenke et al., 2009).*$p < .005$ following Bonferroni correction (.05/10 = .005). Alpha coefficients for all multi-item measures are presented on the diagonal.

Table 6

Bivariate Correlations and Alpha Reliabilities for 6-months Post-Surgery

Variable	1	2	3	4	5
1. RIAI	.90				
2. K-SES	-.01	.90			
3. PHQ	.62*	.-.04	.90		
4. Ability	.29	-.10	-.15	-	
5. % Recovery	-.28	.39	-.23	-.10	-

Notes: RIAI = Re-injury Anxiety Inventory (Walker et al., 2010); K-SES = Knee Self-Efficacy Scale (Thomeé et al., 2003, 2006); PHQ = Patient Health Questionnaire-4 (Kroenke et al., 2009).*$p < .005$ following Bonferroni correction (.05/10 = .005). Alpha coefficients for all multi-item measures are presented on the diagonal.

Table 7

Bivariate Correlations and Alpha Reliabilities for 9-months Post-Surgery

Variable	1	2	3	4	5	6
1. RIAI	.92					
2. K-SES	.12	.78				
3. PHQ	.62*	-.11	.56			
4. Ability	.32	.01	.20	-		
5. % Recovery	.51*	-.38	-.29	-.43*	-	
6. Disablement	.60*	-.68*	.32	-.68*	-.68*	.91

Notes: RIAI = Re-injury Anxiety Inventory (Walker et al., 2010); K-SES = Knee Self-Efficacy Scale (Thomeé et al., 2003, 2006); PHQ = Patient Health Questionnaire-4 (Kroenke et al., 2009).*$p < .005$ following Bonferroni correction (.05/10 = .005). Alpha coefficients for all multi-item measures are presented on the diagonal.

Descriptive Statistics

Participants in the present study were administered a battery of tests at 4-, 6-, and 9-months post-surgery. These tests included measures of cognitive states (i.e., knee self-efficacy, perceived percent recovery, perceived activity limitations), affective states (e.g., re-injury anxiety, mental health), behavioral state (i.e., adherence to treatment), as well as perceived disablement and return to play status. A summary of descriptive statistics on each measure at each of the three time points is provided in Table 8. Descriptive data on adherence revealed little variability and a high mean suggesting a possible ceiling effect. It appears participants were over-reporting their adherence to rehabilitation and results may not accurately represent actual adherence behavior. We intended to address this potential limitation with the use of health care professional reporting of adherence; however, this data was not useable due to inconsistencies in reporting. Additionally, unlike the other psychological measures, adherence did not specify the time frame for reporting. Specifically, participants were not directed to reflect on a specific number of

days or weeks when reporting their adherence as they were with other measures. Therefore, the results may indicate participants' general impression of adherence over the course of rehabilitation, overuse the state-like reporting as was our intention. Thus, adherence was excluded from further analyses.

Table 8

Descriptive Statistics of Psychological Response Measure at 4-, 6-, and 9-months post-ACL Surgery

		4-months post-surgery			6-months post-surgery			9-months post-surgery		
Model Component	Measure	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Cognitions	Knee Self-Efficacy	5.81	2.07	1.50 - 9.80	5.77	1.47	2.70-8.30	7.20	1.31	4.00-10.00
	Perceived Percent Recovery	60.94	17.48	20.00-100.00	76.33	10.66	50.00-90.00	88.44	8.84	70.00-100.00
	Perceived Limitations to Ability	8.06	3.05	0.00-10.00	4.07	3.12	0.00-8.00	2.09	3.00	0.00-8.00
Affects	Re-Injury Anxiety	31.16	8.86	16.00-53.00	17.13	9.26	3.00-42.00	12.71	9.90	0.00-37.00
	Mental Health	5.06	1.41	4.00 – 10.00	1.13	2.06	0.00-7.00	0.81	1.20	0.00-5.00
Behaviors	Adherence	7.72	1.82	4.00-10.00	7.73	1.47	5.00-10.00	7.31	1.89	4.00-10.00
Outcomes	Perceived Disablement							29.87	10.35	16.00-55.00

Table 9

Psychological Responses at 4-, 6-, and 9-months Post-Surgery Divided by Return Status - Returners and Non-Returners

		Measures									
			RIAI		K-SES		PHQ-4	% Recovery			Ability
Time	Return Status	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4 months post-surgery	Returners	29.67	9.00	5.81	2.35	4.94	1.06	60.44	10.62	7.72	3.61
	Non-returners	32.29	8.60	5.81	1.73	5.21	1.81	50.64	10.87	8.50	2.18
6 months post-surgery	Returners	15.67	8.62	6.28	1.33	0.72	1.74	80.56	8.02	3.61	3.13
	Non-returners	19.32	8.14	5.00	1.39	1.75	2.42	70.00	11.28	4.75	3.11
9 months post-surgery	Returners	8.72	5.03	6.96	1.28	0.39	0.70	93.89	5.02	.50	1.89
	Non-returners	18.23	11.76	7.53	1.33	1.38	1.50	81.43	7.70	4.14	2.93
Maximum range possible			0 - 60		0 - 10		0 - 12		0 - 100		0 - 10

Note. RIAI= Re-injury anxiety inventory (Walker et al., 2009), K-SES = Knee self-efficacy inventory (Thomeé et al., 2003, 2006), PHQ= Patient health questionnaire (Kroenke et al., 2009), % Recovery = Single item from ERAIQ (Smith et al., 1990), Ability = Perceived limitations to ability single item from activity scale (Agel, 2013).

Research Question 1

A 2 (Return Status) x 3 (Assessment Time) RM MANOVA revealed a significant return status-by-assessment time interaction, Wilks' Lambda = .58, $F(6,22) = 2.67$, $p<.05$, $\eta^2=.42$, indicating that group differences depended on time of assessment or that change over time depended on group status. A univariate ANOVA revealed that the significant difference was limited to re-injury anxiety $F(2)=4.21$, $p<.05$, $\eta^2= .14$. Independent sample t-tests with a Bonferroni adjustment revealed that returners showed a significant linear reduction in re-injury anxiety from 4-months to 6-months post-surgery $F(1,17)=49.16$, $p<.001$, $d=1.59$ and from 6- to 9-months post-surgery $F(1,17)=18.52$, $p<.001$, $d=.95$. By comparison, non-returners showed a significant reduction in re-injury anxiety from 4-months to 6-months post-surgery $F(1,10) = 49.84$, $p<.001$, $d=1.84$ but no significant change between 6- and 9-months post- surgery $F(1,10)=.32$, $p=.58$. Returners and non-returners did not differ on level of re-injury anxiety at 4- and 6-months post-surgery but returners were significantly lower in re-injury anxiety at 9-months post-surgery $F(1, 27)=4.26$, $p<.05$, $d=1.05$. Means and standard deviations for both levels of return status at each time point for all dependent variables are available in Table 9. Figure 4 shows the group by time interaction effect for re-injury anxiety. Figure 5 shows the non-significant group-by-time interaction for knee self-efficacy and Figure 6 shows the non-signification group by time interaction for mental health.

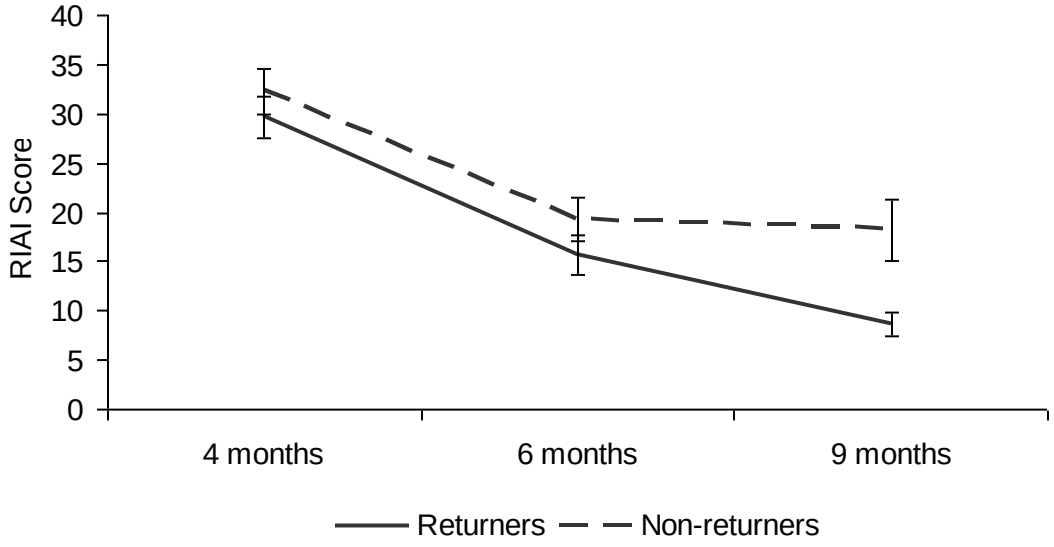

Figure 4. Plot of significant interaction for Re-injury anxiety inventory (RIAI) scores for returners (n = 18) and non-returners (n = 14) to sport at 4-, 6-, and 9-months post-surgery. Error bars represent ± SE. $F(2)=4.21$, $p<.05$, $\eta^2= .14$.

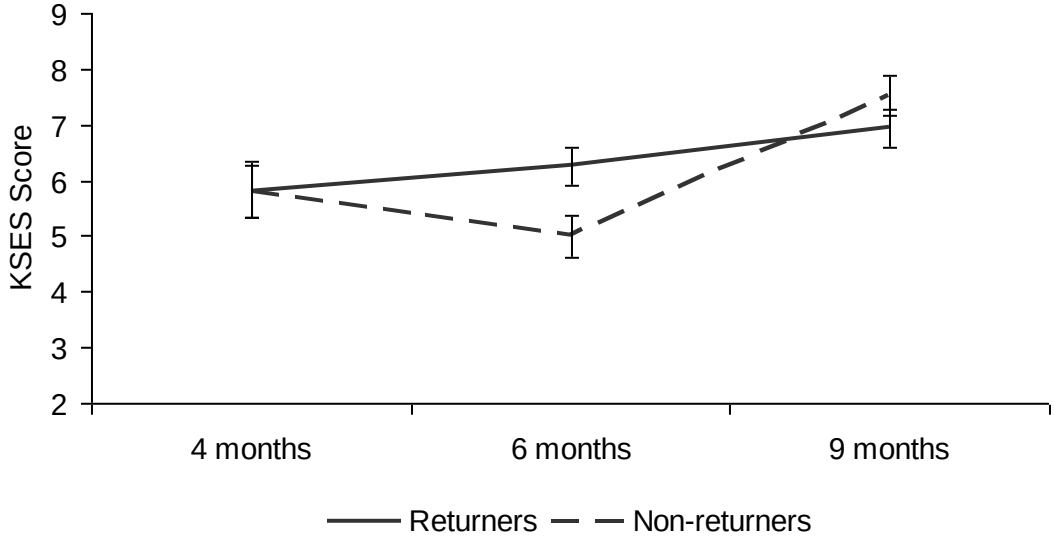

Figure 5. Plot for non-significant interaction for knee self-efficacy (K-SES) scores for returners (n = 18) and non-returners (n = 14) to sport at 4-, 6-, and 9-months post-surgery. Error bars represent ± SE.

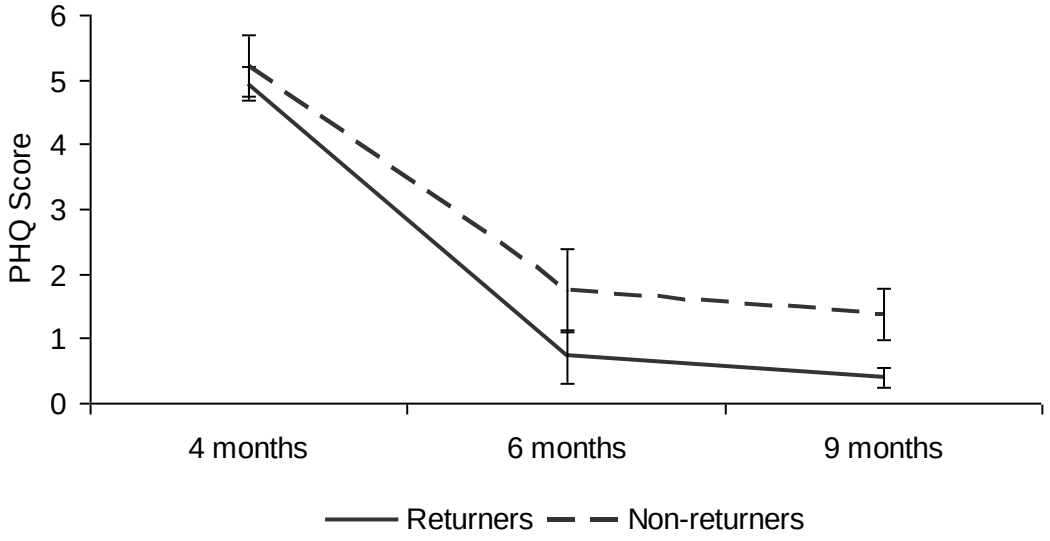

Figure 6. Plot for non-significant interaction for Patient Health Questionnaire (PHQ) scores for returners (n = 18) and non-returners (n = 14) to sport at 4-, 6-, and 9-months post-surgery. Error bars represent ± SE.

In addition to the significant return status-by-assessment time interaction there was significant main effect of time Wilks' Lambda = .06, $F(6,22) = 54.24$, $p<.001$, $\eta^2 = .94$, meaning that both groups changed over time. A univariate ANOVA revealed a significant main effect for time for re-injury anxiety $F(2)=76.58$, $p<.05$, knee self-efficacy $F(1.66) = 9.58$, $p<.05$, and mental health $F(2) = 95.67$, $p<.05$. Independent sample t-tests showed that knee self-efficacy did not change significantly from 4- to 6-months post-surgery ($M_{diff}= .045$) $p = 1.0$; however, it did increase significantly from 6- to 9-months ($M_{diff} = 2.74$) $p<.001$, $d = 1.03$. There was a significant improvement in mental health from 4- to 6-months post-surgery ($M_{diff} = 3.98$) $p<.05$, $d=2.59$ but there was no significant change in mental health from 6- to 9-months post-surgery ($M_{diff} = .12$), $p = 1.0$. There was no main effect for return status $F(3, 25) = 1.74$, $p>.05$, $\eta^2 = .17$, Wilks' Lambda = .83.

Research Question 2

A 2 (Return Status) x 3 (Assessment Time) RM MANOVA showed there was not a significant interaction between return status and time Wilks' Lambda = .85, $F(4,25) = 1.11$, $p = .37$, $\eta^2 = .15$ indicating that change over assessment times was not dependent on return status and group differences were not dependent on time. Figures 7 and 8 show the non-significant group by time interactions for perceived percent recovery and perceived limitations respectively. There were significant main effects for return status Wilks' Lambda = .58, $F(2,27)=10.08$, $p<.001$, $\eta^2 = .42$ and assessment time Wilks' Lambda = .21, $F(4,25) = 23.19$, $p<.05$, $\eta^2 = .79$.

Independent sample t-tests with a Bonferroni adjustment were used to examine the main effect of return status. Returners reported a significantly higher percent of perceived recovery ($M_{diff} = 11.57$), $p<.01$, $d=1.22$ and lower perceived limitations to ability ($M_{diff} = 2.08$), $p<.01$, $d = .66$ as compared to non-returners. Independent sample t-tests with a Bonferroni adjustment revealed that there was a significant increase in perceived percent recovery from 4-months post-surgery to 6-months post-surgery ($M_{diff} = 16.39$), $p<.001$, $d = 1.06$ and between 6- and 9-months post-surgery ($M_{diff} = 12.08$), $p<.001$, $d = 1.24$. There was a significant reduction in perceived limitations to ability from 4-months post-surgery and 6-months post-surgery ($M_{diff} = 4.31$), $p<.001$, $d = 1.29$ and between 6-months and 9-months post-surgery ($M_{diff} = 1.89$), $p<.05$, $d = .65$. Means and standard deviations for both levels of return status at each time point for all dependent variables are available in Table 9.

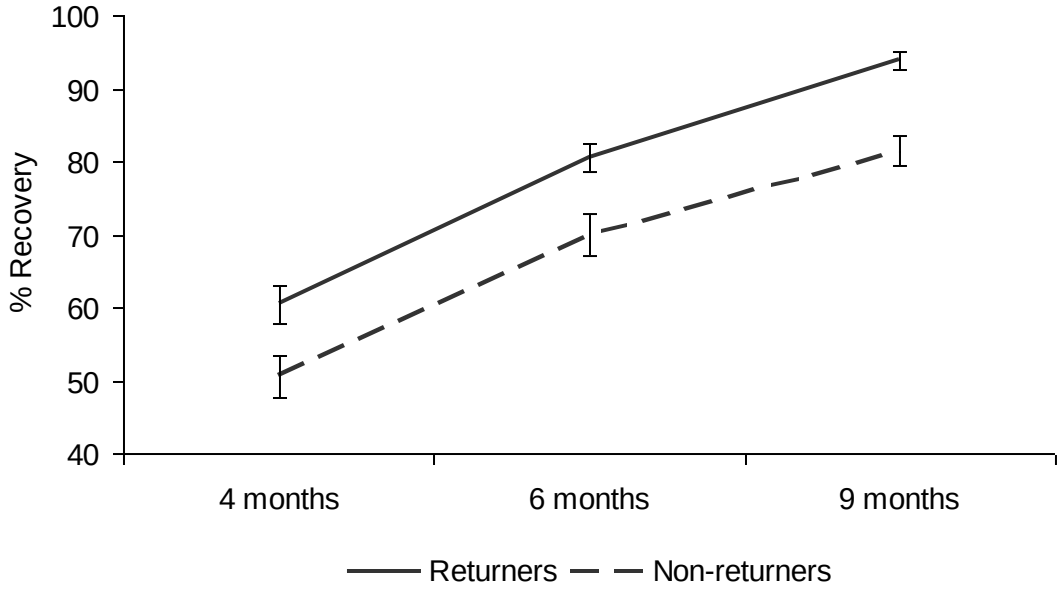

Figure 7. Plot of non-significant interaction for perceived percent recovery scores for returners (n = 18) and non-returners (n = 14) to sport at 4-, 6-, and 9-months post-surgery. Error bars represent ± SE.

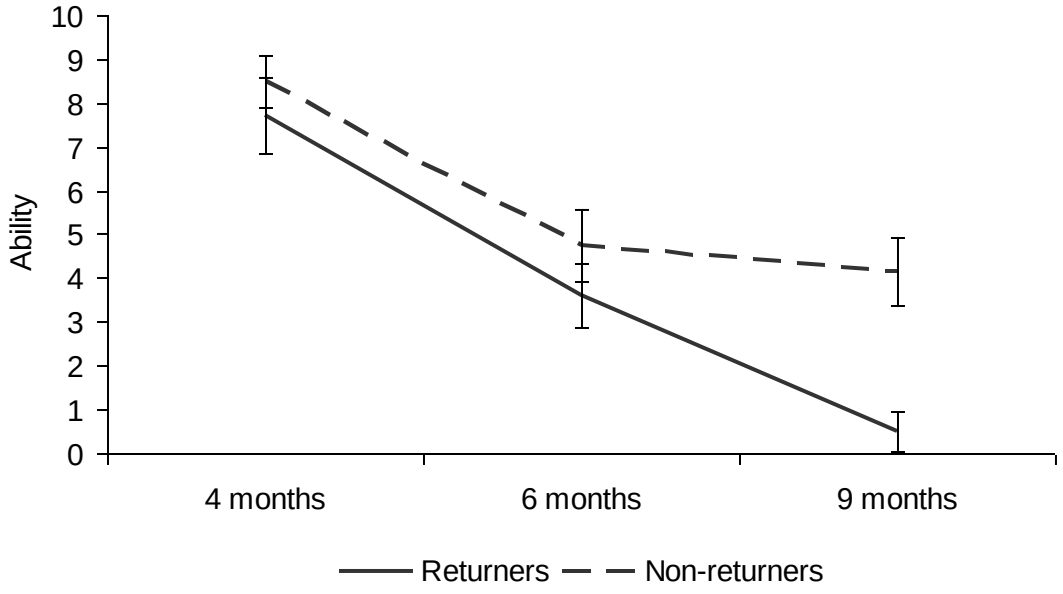

Figure 8. Non-significant interaction of limitations to ability scores for returners (n = 18) and non-returners (n = 14) to sport at 4-, 6-, and 9-months post-surgery. Error bars represent ± SE.

Research Question 3

The first of two stepwise regression analyses assessed if psychological responses at 4-months post-surgery predicted perceived disablement at 9-months post-surgery. In order to control for developmental differences, age was entered in the first step in the stepwise regression. In the first step of the regression, age was not found to be a significant predictor of perceived disablement. The second step of the analysis was also not significant $F(6,24) = 2.31$, $p>.05$, $R^2 = .37$ indicating that the psychological responses variables assessed at 4-months post-surgery did not account for a significant amount of variance in perceived disablement at 9-months post-surgery. Table 10 displays the stepwise multiple regression results for the test of the model using psychological assessment at 4-months post-surgery.

The second stepwise regression assessed if psychological responses at 6-months post-surgery predicted disablement at 9-months post-surgery. Like in the first regression analysis in order to control for developmental differences, age was entered in the first step in the stepwise regression. In the first step of the regression, age was not found to be a significant predictor of perceived disablement. The second step of the analysis was significant $F(6,22) = 4.08$, $p<.05$, $R^2 = .53$ indicating psychological responses at 6-months post-surgery explained a significant amount of variance in perceived disablement at 9-months post-surgery. Examination of the regression coefficients revealed perceived percent recovery ($\beta = -.47$), $p<.05$ contributed significantly to the model. Table 11 displays the stepwise multiple regression results for the test of the model.

Since at 9-months post-surgery were assessed at the same time as the outcome measure bivariate correlations were conducted to determine the relationship between psychological response variables and perceived disablement. Bivariate correlations revealed that re-injury anxiety ($r = .60$), perceived percent recovery ($r = -.68$) and perceived limitations to ability ($r = .49$) at 9-months post-surgery were all significantly correlated with perceived disablement at 9-months post-surgery.

Table 10

Stepwise Multiple Regression Results of Psychological Response Variables at 4 Months Predicting Perceived Disablement at 9 Months Post-Surgery

	SE	Beta	*t*	*p*
Age	.25	.28	1.65	.11
RIAI	.31	.27	1.34	.19
K-SES	-.90	-.18	-1.00	-1.0
PHQ	1.12	.15	.77	.77
% Recovery	-1.96	-.33	-1.65	.11
Ability	-.50	-.15	-.69	.49

Note. RIAI = Re-injury anxiety inventory (Walker et al., 2010); K-SES = Knee self-efficacy scale (Thomeé et al., 2003, 2006); PHQ = Patient health questionnaire-4 (Kroenke et al., 2009); % Recovery = Single item from ERAIQ (Smith et al., 1990), Ability = Perceived limitations to ability single item from activity scale (Agel, 2013).

Table 11

Stepwise Multiple Regression Results of 6 Month Psychological Response Variables Predicting Perceived Disablement at 9 Months Post-Surgery

	SE	Beta	*t*	*p*
Age	.27	.29	1.56	.13
RIAI	-.14	-.12	-.56	.58
K-SES	-.72	-.10	-.52	.61
PHQ	2.37	.45	2.06	.05
% Recovery	-4.59	-.47	-2.68	.01
Ability	.44	.13	.73	.47

Note. RIAI = Re-injury anxiety inventory (Walker et al., 2010); K-SES = Knee self-efficacy scale (Thomeé et al., 2003, 2006); PHQ = Patient health questionnaire-4 (Kroenke et al., 2009); % Recovery = Single item from ERAIQ (Smith et al., 1990), Ability = Perceived limitations to ability single item from activity scale (Agel, 2013).

Summary of Significant Results

Research question 1.

- There was a significant return status-by- assessment time interaction for re-injury anxiety.

    - Returners and non-returners did not differ on re-injury anxiety at 4- or 6-months post-surgery but returners were significantly lower on re-injury anxiety at 9-months than non-returners.
- There was a significant main effect for assessment time for knee self-efficacy and mental health.
    - Knee self-efficacy did not change from 4- to 6-months post-surgery but improved from 6- to 9-months post-surgery.
    - Mental health improved significantly from 4- to 6-months post-surgery but did not change from 6- to 9-months post-surgery.

Research question 2.

- There was a significant main effect for return status for perceived percent recovery and perceived limitations to ability.
    - Returners were significantly higher in perceived percent recovery than non-returners.
    - Returners were significantly lower in perceived limitations to ability than non-returners.
- There was a significant main effect for assessment time for perceived percent recovery and perceived limitations to ability.
    - Perceived percent recovery increased significantly from 4- to 6-months post-surgery and from 6- to 9-months post-surgery.
    - Perceived limitations to ability decreased significantly from 4- to 6-months post-surgery and from 6- to 9-months post-surgery.

Research question 3.

- Psychological variables assessed at 6-months post-surgery predicted perceived disablement at 9-months post-surgery.
    - Perceived percent recovery contributed significantly to this model.
- Re-injury anxiety, perceived percent recovery, and perceived limitations to ability at 9-months post-surgery were all significantly correlated with perceived disablement at 9-months post-surgery.

CHAPTER 4

Discussion

The first purpose of this study was to determine if athletes that returned to play and athletes that did not return to play after ACL reconstruction surgery would differ on psychological responses across the ACL rehabilitation process. We found that returners differed from non-returners on fear of re-injury at 9-months post-surgery with returners indicating lower levels of fear of re-injury. Returners were higher in perceived percent recovery than non-returners and lower in perceived limitations to ability than non-returners. Returners and non-returners improved in perceived percent recovery and perceived limitations to ability over time. The second purpose of this study was to determine if psychological responses would predict perceived disablement. We found that perceived percent recovery at 6-months post-surgery predicted perceived disablement at 9-months post-surgery.

This study extends the currently literature by using a repeated measures design to explore the experiences of athletes post-ACL reconstruction surgery across the latter course of rehabilitation. The present study also used sport specific measures, explored a number of different psychological responses, and examined the construct of return to play more broadly than has been done in previous research by considering also the larger context of disablement theory. Several of these results are consistent with previous research while others refute what has previously been found. The following section will place these results in the context existing literature on psychological responses to ACL

injuries and rehabilitation outcomes and the chronology of psychological responses to ACL injuries.

Psychological Responses and Rehabilitation Outcomes

Consistent with the findings of previous research (Ardern et al., 2011; Brophy et al., 2012; Kvist, 2004, Kvist et al., 2005; Langford et al., 2009), approximately half of the participants in this study returned to sport by 9-months post-surgery. All non-returners indicated that they had not returned to sport due to injury related concerns, including not feeling ready, fear of re-injury, or knee related symptoms. Researchers have consistently established that the most common attributions for not returning to play post-ACL rehabilitation are fear of re-injury and continued knee symptoms (Flanigan et al., 2013; McCullough et al., 2012; Tjong et al., 2014).

Cognitions. We examined cognitive responses, specifically, knee self-efficacy, perceived limitations to ability, and perceived percent recovery, to determine their relation with rehabilitation outcomes. In cognitive-behavioral models such as Wiese-Bjornstal et al.'s (1998) integrated model of psychological response to sport injuries suggest cognitions are central to influencing feelings and behaviors and ultimately rehabilitation outcomes. Results of our analyses revealed no significant change in knee self-efficacy over the course of ACL rehabilitation. This is inconsistent with previous research by Thomeé et al (2007) who found a significant linear increase in knee self-efficacy. These results could be explained by our use of only the most relevant subscales in our assessment of knee-self efficacy – physical activity and future knee function, whereas Thomeé et al. included activities of daily living in their assessment of changes in

knee self-efficacy. Additionally, the level of knee self-efficacy reported by participants was already high at 4-months, thus there may have been little room for it to improve throughout rehabilitation.

A unique aspect of this study was the inclusion of cognitions about recovery as potential contributors to rehabilitation outcomes, which have both emerged in qualitative research (Flanigan et al., 2013) as being associated with rehabilitation outcomes post-ACL surgery. Consistent with previous research participants who returned to sport revealed perceptions of greater recovery, over 11% higher, and reported lower limitations to ability than participants who did not return to play. The present study supports pervious qualitative findings insofar as athletes who did not return to play after ACL surgery cited cognitions related to perceived continued knee-related symptoms and limitations to functional ability as reasons why they have not recovered or returned to play (Flanigan et al., 2013; Heijne et al., 2008).

Affects. Consistent with the literature both groups revealed a significant decline in levels of fear of re-injury between 4-months and 6-months. Returners revealed a significant linear decline in fear of re-injury across the entire course of rehabilitation from 4-month to 9-months. Non-returners, on the other hand, showed a significant decline in fear of re-injury from 4- to 6-months post-surgery followed by a plateauing with no significant change from 6- to 9-months. At 9-months post-surgery returners were significantly lower in re-injury anxiety than non-returners but the groups did not differ at the other two time points.

Finding that fear of re-injury differentiated between returners and non-returners is consistent with previous research. Fear of re-injury early in rehabilitation is predictive of return to play (Ardern et al., 2013b). Fear of re-injury is also associated with function and timing of return to play (Chmielewski et al., 2008) and athletes have retrospectively reported it as a common explanation for why they do not return to play (Tjong et al., 2014). A unique contribution of the present findings; however, is the prospective examination of levels of fear of re-injury and rehabilitation outcomes across the latter course of ACL rehabilitation. This is different from much of the previous research that has looked at level of fear of re-injury retrospectively (Kvist et al., 2005; Tjong et al., 2014), at time points very early in rehabilitation (Ardern et al., 2013b) or cross-sectionally (Chmieleski et al., 2008).

The between group differences in reduction of fear of re-injury over time might be explained by the nature of ACL rehabilitation goals at different time points post-surgery. Specifically, in the months immediately following ACL reconstruction surgery, some degree of fear of re-injury is adaptive, preventing athletes from doing activities that might put them at risk of re-injuring their knee (Kori et al., 1990; Tripp et al., 2007). By 6 months post-surgery, however, ACL rehabilitation involves increased exposure to sport specific training (Delay et al., 2000; Heijne et al., 2008; Stoehr et al., 2014). This increased exposure may differentiate those athletes with greater sport-specific and, perhaps, more psychopathological anxiety. For these individuals, sport-specific training exercises would activate their fear response and possibly lead to avoidance behavior, such as not returning to play.

Both Chmielewski et al. (2008) and Roos (2010) have suggested that the fear-avoidance model (Waddell et al., 1993) might account for the relationship between fear of re-injury and return to play outcomes. In research on individuals with low back pain, fear of movement and re-injury predicted activity avoidance and contributed to chronic pain and inactivity (Asmundson, Norton, & Allerdings, 1997; Vlaeyen, Kole-Snijders, Boeren, & van Eek, 1995; Wideman, Adams, & Sullivan, 2009). Although escape behaviors, such as avoidance of sport specific training or delaying returning to play, can decrease fear of re-injury in the short term it may actually increase the fear over time rendering the athlete unable or unwilling to return to play (Leeuw et al., 2006). Specifically, avoidance of situations which elicit fear or anxiety, including avoidance of sport-specific training and returning to play, do not allow athletes to be exposed to the anxiety provoking stimuli and, therefore they have no chance of disproving their beliefs that they will get re-injured should they return to play (Leeuw et al., 2009; Stewart & Watt, 2008).

In our study, we found that returners and non-returners did not differ on levels of fear of re-injury at 4- or 6-month post-surgery; however, non-returners have significantly higher fear of re-injury at 9-months post-surgery and there was a large effect size for this difference indicating it was both statistically and meaningfully different. This provides support for the fear-avoidance model in that returners may have been less likely to avoid sport specific training around 6-months post-surgery thus exposing themselves to fear evoking stimuli and subsequently decreasing their fear of re-injury. Conversely, non-returners maintained an elevated level of fear of re-injury from 6- to 9-months post-

surgery, as compared to the returners, indicating they may have avoided the sport specific training and ultimately maintained their fear of re-injury.

This is not to say that re-injury is not a realistic concern for athletes returning to play after ACL injury. Athletes who experience ACL tears are at an increased risk of re-injury or injury to the contralateral knee as compared to athletes who have not suffered ACL tears (Kamath et al., 2014; Paterno, Rauh, Schmitt, Ford, & Hewett, 2014; Walden, 2013). In the present sample, however, all participants reported, at 4-months post-surgery, an intention to return to play thus indicating they were not meeting their goals or expectations regarding return to play.

Mental health was another important variable of interest in our study. To our knowledge, this is the first time the PHQ-4 (Kroenke et al., 2009) has been used to examine psychological response to injury. We selected this measure because of its ease of use in a sport rehabilitation setting given its simple language and short length. Additionally, it screens for psychopathology – anxiety and depression – which are real concerns for athletes post-injury (Appaneal et al., 2009; Smith et al., 1990). Additionally, versions of the PHQ are often used as routine mental health screening tools in medical settings.

Outcomes. Another unique aspect of the present study was the inclusion of an assessment of perceived disablement as an outcome measure. Although athletes' most important outcome post-ACL rehabilitation surgery is often return to play (Heijne et al., 2008), according to Vela and Denegar (2010a) return to play is contained within the much larger context of disablement. Specifically, Vela and Denegar have suggested that

failure to return to play is a disability that is affected by and, in turn, affects the injury pathology, symptoms of impairment, and functional limitations, thereby ultimately contributing to an athletes' overall quality of life.

Consistent with previous research specifically focusing on return to play as the outcome (Ardern et al., 2013b; Kvist et al., 2005; Langford et al., 2009), psychological responses to injury across rehabilitation emerged as important predictors of the larger construct of disablement in the present study. More specifically, psychological responses (i.e., knee-self-efficacy, re-injury anxiety, mental health, perceived percent recovery, and perceived limitations to ability) at 6-months post-surgery predicted perceived physical disablement at 9- months post-surgery, and psychological responses assessed at 9-months post-surgery were correlated with disablement at 9-months post-surgery. The psychological responses that were associated with disablement at 9-months post-surgery differed at each time point. Specifically, at 6-months post-surgery perceived percent recovery accounted for a significant amount of variance in the model, while at 9-months post-surgery re-injury anxiety, perceived percent recovery, and perceived limitations to ability were all significantly correlated with perceived disablement at the same time assessment.

Previous research has focused on components of disablement theory – specific impairments, functional limitations, or returned to play –rather than disablement as a larger construct including impairments, functional limitations, disability, and quality of life. Much of the research on psychological responses and their relationships with outcomes have focused primarily on return to play and have been cross-sectional

(Chmielewski et al., 2008) or retrospective in design (Kvist et al., 2005; McCullough et al., 2012 Tjong et al., 2014). Little research has examined how psychological responses predict recovery outcomes using a prospective repeated measures design (e.g., Ardern et al., 2013b; Langford et al., 2009) and those that have, focused almost exclusively on return to play as the most important outcome. Although we acknowledge that for most athletes return to play is their most important outcome, examining disablement as a broader construct allowed us to examine a more holistic view of disability post-injury. Understanding ways in which athletes who have been medically cleared to return to sport still feel disabled helps us evaluate why so many athletes do not return to play at the same level, return but drop out sooner than might be expected, or choose to end their careers by not returning at all.

Results of the present study provide support for a temporal association between psychological response to injury and perceived disablement. At 6-months post-surgery cognitions about recovery emerged as the most important predictors of disability, whereas at 9-months post-surgery re-injury anxiety as well as cognitive variables were associated with disablement. This provides support for the disablement theory of sport injury proposed by Vela and Denegar (2010a). General disablement theories have been used in health care fields to assess patient progress and outcomes. Vela and Denegar's model of disablement in physically active populations outlines how disablement theories describe the sequence of events that occur after injuries within physically active populations. Results of the present study appear consistent with this model.

Overall, the results of this study support the theoretical framework that Wiese-Bjornstal et al. (1998) provide describing the relationship between psychological response to injury and recovery outcomes. Results indicated psychological responses were associated with ACL injury recovery outcomes of return to play and perceived disability at 9-months post-ACL reconstruction surgery. Specifically, it appears that cognitions are most important early in the rehabilitation while affects have the most influence during returning to play later in rehabilitation. These results also highlight that athletes experience significant psychological distress and perhaps even psychopathology during the mid to latter periods of ACL recovery, with the mean scores on the PHQ-4 at 4-months post-surgery well above clinical screening cutoffs for additional evaluation and indicating moderate levels of anxiety and depression.

Chronology of Psychological Responses

This study was unique in that we could also assess the chronology of psychological responses to injury over time. As previously discussed, evidence on the chronology of psychological responses over the course of ACL rehabilitation is mixed. Some researchers have found a consistent decrease over time (Brewer et al., 2007; Langford et al., 2009), whereas other researchers have found a more dynamic psychological response to injury where an "emotional U" pattern of an initial decrease in psychological distress post-surgery followed up an increase in psychological distress later in rehabilitation (LaMott et al., 1994; Morrey et al., 1999), or specifically at return to play (Podlog & Eklund, 2005, 2006). Our results show partial support for both of these hypotheses.

Results of the present study found that re-injury anxiety decreased significantly over the course of rehabilitation, but differently for returners and non-returners. For the returners group, re-injury anxiety decreased across the course of rehabilitation, whereas the non-returners did not change in re-injury anxiety from 6- to 9-months post-surgery. This supports the idea that psychological distress decreases over the course of rehabilitation from ACL surgery; however, this is only true for some athletes – returners but not non-returners. For the non-returners group, this shows more support for the "emotional U" pattern where re-injury anxiety may not necessarily increase in the later part of rehabilitation but it also does not decrease as would be expected (Chmielewski et al., 2008; Langford et al., 2009).

Knee self-efficacy provided further support for the idea that psychological distress does not decrease linearly though the course of ACL rehabilitation. This is inconsistent with previous research specifically focusing on knee self-efficacy that has shown a linear increase in knee self-efficacy over time course of ACL rehabilitation (Thomeé et al., 2007) although examining the construct at slightly different time points (3-, 6-, and 12-months post-surgery). There was no significant return status-by-assessment time interaction for knee self-efficacy; however, there was a main effect for time indicating that knee self-efficacy changed over the three time periods assessed. Knee self-efficacy did not change from 4- to 6-months post-surgery and subsequently increased significantly from 6- to 9-months post-surgery. The small sample size and resulting low power might explain the lack of significant change between 4- and 6-months post-surgery. The univariate test for knee self-efficacy in the interaction effect is approaching significance

and examination of the means and plot for knee self-efficacy shows the non-returners appear to decrease in knee self-efficacy from 4- to 6-months post-surgery while the returners seem to remain relatively unchanged (although this interaction is not statistically significant). Therefore, with a larger sample size an interaction effect may have explained this pattern of knee self-efficacy over ACL rehabilitation.

The main effect for time for mental health also did not show a linear improvement over the course of rehabilitation. It did; however, provide further support for concerns about psychopathology post-sport injury (Appaneal et al., 2009; Smith et al., 1990). At 4-months post-surgery the mean score on the PHQ-4 would be considered in the moderate severity range based on the clinical cut off criteria for its parent measure (PHQ-9) suggesting a treatment plan, counseling, and/or pharmacotherapy is recommended (Pfizer, 2014). It is also well above the cutoff for mild severity of depression and anxiety for which follow up assessment be considered. Mental health improved significantly (i.e., PHQ-4 scores decreased) from these concerning scores at 4-months post-surgery to what would be considered mild to minimal risk for anxiety or depression at 6-months post-surgery. There was no significant difference between mental health scores at 6- and 9-months post-surgery with participants still showing a low risk of clinical depression or anxiety.

With respect to the cognitions related to perceived recovery – perceived percent recovery and perceived limitations to ability – there was partial support for continued psychological improvement across the course of ACL rehabilitation. There was a significant main effect of time and both variables significantly contributed to the effect.

Perceived percent of recovery increased significantly from each time point with participants perceiving themselves to be 60% recovered at 4-months post-surgery to almost 90% by 9-months post-surgery showing a significant improvement in perceived recovery across rehabilitation. For perceived limitations to ability there was a significant decrease in perceived limitations from 4-, to 6-months post-surgery but no significant change from 6- to 9-months post-surgery. These results suggest that cognitions about recovery also do not necessarily improve linearly over the time periods assessed, specifically, they may return to baseline levels of 6-months post-surgery.

Overall, it appears that psychological responses in terms of knee self-efficacy, cognitions about limitations to ability, re-injury anxiety, and mental health improve from 4- to 6-months post-surgery while showing little change from 6- to 9- months post-surgery and re-injury anxiety changes differ depending on if an athlete returns to sport at 9-months post-surgery. The only variables that showed consistent improvement across ACL rehabilitation were cognitions related to percent perceived recovery, which improved from each time point. Based on these results we cannot assume psychological responses will improve consistently across the course of rehabilitation.

Limitations and Future Research

Although this study extended past research and added to the understanding of psychological responses of returners and non-returners over time and their relationship to rehabilitation outcomes there were a number of limitations. The first limitation of this study was the sample size. Due to the specific nature of inclusion criteria as well as problems with follow through with returning informed consent forms, the sample size for

this study was low. With decreased sample size there is decreased power therefore the chance of Type II error – failing to reject the null hypothesis – is increased. Therefore, based on the limited sample size of this study it is possible that there were missed significant effects that in this study.

There were also limitations in some of the measures. Specifically, the measure of adherence seemed to have a self-presentation bias wherein participants may have reported their adherence to rehabilitation in order to present themselves more positively. Alternatively, this could have been a highly motivated population who adhered well to rehabilitation protocol. Our initial intention was to include health care provider ratings of adherence; however, due to inconsistencies in medical records there was too much missing data to be used in analyses. Therefore, this presented another reason why we felt unable to use the self-report adherence data in the analyses. In order to prevent this in a future study, health care provider reported adherence should also be included in order to triangulate the adherence scores. Additionally, we used two single item scales in this study. Although they both have good face validity, single item measures are limited in that they could not be tested on psychometric properties.

A third limitation of this study is that lack of inclusion of physical data as we cannot account for physical differences in recovery in participants that may explain scores on psychological responses and outcomes measures. I intended to collect physical data for this study, however, after examining health care providers' charts it was evident that there were inconsistencies in the physical data assessed and recorded by different providers. This highlights an important problem in sports medicine research in that there

is a discrepancy between what health care providers record for patient care and what researchers need to access. The absence of physical measures in this study limits our ability to draw conclusions about the strength of the relationships between psychological responses and rehabilitation outcomes. Based on the design of this study we cannot draw causal attributions between the psychological response variables and injury outcomes; however, we are further limited in drawing conclusions by not being able to assess physical recovery outcomes in participants. We cannot determine if physical healing or functional variables could confound the relationships between psychological responses and outcomes. Finally, there was a large range of ages of participants in this study, and analyses revealed that returners were significantly younger than non-returners. Therefore, we cannot account for the role of developmental differences in participants in this study.

In order to address these limitations and extend the literature on psychological responses and recovery from ACL injuries future studies should continue to examine the experiences of athletes' post-ACL reconstruction surgery in a number of different ways. First, this study should be replicated with a larger sample size and the addition of physical recovery progress variables as predictors of return to play post-ACL reconstruction surgery. Second, studies involving randomized controlled interventions could determine if there are causal relationships between psychological responses to ACL injury and return to play outcomes that could benefit from psychological interventions. For example, since fear of re-injury has consistently had the most support as a psychological predictor of return to play this would be a logical focus of intervention.

Thus, from a fear-avoidance model perspective conducting an intervention using systematic desensitization to expose athletes to the fear evoking stimuli in a controlled manner early in rehabilitation could reduce anxiety and subsequently improve return to play success.

Third, it is important to translate what we know about psychological responses and rehabilitation outcomes into clinical practice. In our study, we selected short and easy to administer questionnaires that have the potential to be used by health care professionals to identify athletes who, from a psychological perspective, are at risk for negative rehabilitation outcomes such as not returning to play. Therefore, researchers should examine if use of these measures or development of clinically relevant tools to identify athletes who may not return to play is possible.

Conclusions

In an ideal world, we would be able to identify athletes at risk of not returning to play after ACL injuries through repeated physical and psychological measures throughout ACL rehabitlition. This study extends the current literature by employing a prospective longitudinal design to examine the associations between psychological responses and rehabilitation outcomes post-ACL reconstruction surgery. The results of this study further highlight the importance of psychological responses with respect to return to play outcomes. The results indicate that returners and non-returners differ across rehabilitation on thoughts and feelings related to their injuries. Specifically, fear of re-injury is lower in returners than non-returners at 9-months post-surgery and that different psychological responses predict disablement at 9-months post-surgery at different time

points throughout rehabilitation. Cognitions about recovery emerged as most important predictors of perceived disablement early in rehabilitation while affective responses, specifically fear of re-injury, emerged as most important in understanding outcomes at 9-months post-surgery. Future research should extend this work in order to help predict early in rehabilitation athletes who are at risk of poor rehabilitation outcomes and determine ways to improve these outcomes – preventing disablement including inability to return to play.

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Appendix A

Summary of participant characteristics

Summary of Participant Characteristics

Participant	Age	Gender	Sport	Competitive Status	Return Status
1	17	Female	Lacrosse	Competitive	Returner
2	16	Male	Basketball	Competitive	Returner
3	35	Female	soccer	Recreational	Returner
4	32	Female	Football	Competitive	Returner
5	19	Female	Soccer	Recreational	Returner
6	31	Male	Golf	Recreational	Returner
7	21	Male	Football	Competitive	Returner
8	15	Male	Hockey	Competitive	Returner
9	24	Male	Softball	Recreational	Returner
10	45	Female	TaeKwonDo	Competitive	Returner
11	13	Male	Football	Competitive	Returner
12	17	Female	Basketball	Competitive	Returner
13	13	Female	Lacrosse	Competitive	Returner
14	14	Female	basketball	Competitive	Returner
15	38	Female	Downhill skiing	Recreational	Returner
16	19	Male	Football	Competitive	Returner
17	30	Male	Basketball	Recreational	Returner
18	20	Female	Soccer	Competitive	Returner
19	16	Male	Running/Walking	Recreational	Non-Returner
20	31	Female	Running	Recreational	Non-Returner
21	31	Male	Softball	Recreational	Non-Returner
22	48	Female	Tennis	Competitive	Non-Returner
23	58	Male	Downhill skiing	Recreational	Non-Returner
24	32	Female	Karate	Competitive	Non-Returner
25	22	Female	Biking	Recreational	Non-Returner
26	35	Male	Motocross	Competitive	Non-Returner
27	26	Female	Ultimate Frisbee	Competitive	Non-Returner
28	25	Male	Basketball	Recreational	Non-Returner
29	31	Male	Baseball	Recreational	Non-Returner
30	36	Female	Exercise	Recreational	Non-Returner
31	45	Male	Working out	Recreational	Non-Returner
32	16	Female	Soccer	Competitive	Non-Returner

Appendix B

Questionnaires

Demographics

Name: _____

Today's Date: _____/____/_____
mm/dd/yyyy

Birthdate: _____/____/_____
mm/dd/yyyy

Gender: ☐ Male ☐ Female

Date of knee surgery: _____/____/_____
mm/dd/yyyy

Is this your first knee surgery? ☐ Yes ☐ No

If yes please list previous knee surgeries: -
_____
_____
_____

Sport played at time of injury: _____

Did your knee injury occur while playing a sport? ☐ Yes ☐ No

Level of sport played at time of injury:
☐ Junior High school
☐ High school varsity
☐ High school junior varsity
☐ College
☐ Club (please specify level): _____
☐ Regional
☐ National

Do you intend on returning to competitive sport after you have recovered from your knee injury? ☐ Yes ☐ No

Sport intending to play at return to play: _____

Level intended to play upon return to play:
☐ Junior High school
☐ High school varsity

☐ High school junior varsity
☐ College
☐ Club (please specify level): _____
☐ Regional
☐ National

Estimated return to play date: _____/____/_____
mm/dd/yyyy

Most important/favorite sport played: _____

Second most important/favorite sport played:_____

Have you returned to your pre-injury level of sport or physical activity? ☐ Yes ☐ No

Activity Scale (Agel, 2013)

Please provide the following information about your two most favorite/important physical activities (sports, exercise, etc).

Favorite/Most Important Physical Activity

Q1 What is this activity?

_____

Prior to Your Injury

Q2 Prior to your injury:

A How long would you normally participate in this activity?

|__|__| Hours per Time

B On average how many days a week would you participate in this activity?

|__| Days per Week

Current Time

Q3 Do you still engage in this sport or activity?

1 ☐ Yes
2 ☐ No

Q4 How much is your ability to perform in this activity limited by your injury?

0 1 2 3 4 5 6 7 8 9 10
None Completely

If None (0) (Go to Q6 – top of next column)
If Limited (1-10) continue with Q5

Q5 What is the primary reason you are limited in performance in sport or activity anymore?

1 ☐ Your Injury
2 ☐ Other Reason - *Describe:*

_____

Second Most Important Physical Activity

Q6 What is this activity?

_____

Prior to Your Injury

Q7 Prior to your injury:

A How long would you normally participate in this activity?

|__|__| Hours per Time

B On average how many days a week would you participate in this activity?

|__| Days per Week

Current Time

Q8 Do you still engage in this sport or activity?

1 ☐ Yes
2 ☐ No

Q9 How much is your ability to participate in this activity limited by your injury?

0 1 2 3 4 5 6 7 8 9 10
None Completely

If None (0) you are finished
If Limited (1-10) continue with Q10

Q10 What is the primary reason you are limited in performance sport or activity anymore?

1 ☐ Your Injury
2 ☐ Other Reason - *Describe:*

_____

Patient Self-Report Scales of Their Home-Based Rehabilitation Adherence (Basset et al., 2003)

For each of the treatment methods you have been requested by you physiotherapist to do at home please circle the words and numbers that best indicate the extent you have followed the instructions about doing this form of treatment.

Exercises

Not at all	A little	Rather regularly	Very regularly	As advised
1	2	3	4	5

Refraining from undertaking the sporting and daily activities that the rehabilitation personnel advised not to do

Not at all	A little	Rather regularly	Very regularly	As advised
1	2	3	4	5

Re-injury Anxiety Inventory (Walker et al., 2010)

Below are several statements that athletes have used to describe their feelings regarding re-injuries worried. Read each statement and circle the appropriate number to indicate how you feel right now, at this moment.

	Not at all	Somewhat	Moderately so	Very much so
1. I am worried about becoming re-injured during re-entry into competition.	0	1	2	3
2. I feel nervous about becoming re-injured during re-entry into competition.	0	1	2	3
3. I have doubts that I will remain injury free during my re-entry into competition.	0	1	2	3
4. I feel on edge about becoming re-injured during re-entry into competition.	0	1	2	3
5. I am worried that I may not do as well as I could on returning to competition due to my re-injury worries	0	1	2	3
6. My body feels tense about rehabilitation about re-entering competition because of my injury worries.	0	1	2	3
7. I feel confident that I will not become re-injured during re-entry into competition.	0	1	2	3
8. I am worried about failing when re-entering into competition due to re-injury worries.	0	1	2	3
9. Re-injury worries about re-entry into competition make my body feel tense.	0	1	2	3
10. I am worried about performing poorly during re-entry into competition due to re-injury worries.	0	1	2	3
11. I am worried about failing to achieve full re-entry into competition due to re-injury worries.	0	1	2	3
12. I am worried that others will be disappointed if I become re-injured during re-entry into competition.	0	1	2	3
13. The thought of re-injury during re-entry into competition makes my palms sweaty.	0	1	2	3
14. I am worried about concentrating during re-entry into competition because	0	1	2	3

of my re-injury worries.				
15. My body feels tight due to re-injury worries during re-entry into competition.	0	1	2	3

The Knee Self-Efficacy Scale (Thomeé 2003; Thomeé et al., 2006)

Physical Activities

Mark the number that best represents how certain you are about the activity right now despite pain/discomfort.

0=Not at all certain 10= Very certain

How certain are you about:

1) squatting	0 1 2 3 4 5 6 7 8 9 10
2) jumping sideways from one leg to the other	0 1 2 3 4 5 6 7 8 9 10
3) working out hard	0 1 2 3 4 5 6 7 8 9 10
4) doing a one-leg hop on the injured leg	0 1 2 3 4 5 6 7 8 9 10
5) moving around in a rocking small boat	0 1 2 3 4 5 6 7 8 9 10
6) doing fast twisting	0 1 2 3 4 5 6 7 8 9 10

Your knee function in the future

Mark the number that best represents how certain you are about the activity right now despite pain/discomfort.

0=Not at all certain 10= Very certain

1) How certain are you can participate on the same activity level as before the injury?	0 1 2 3 4 5 6 7 8 9 10
2) How certain are you that you will not suffer any new injuries to your knee?	0 1 2 3 4 5 6 7 8 9 10
3) How certain are you that your knee will not "break"?	0 1 2 3 4 5 6 7 8 9 10
4) How certain are you that your knee will not get worse than before surgery?	0 1 2 3 4 5 6 7 8 9 10

Patient Health Questionnaire-4 (Spitzer et al., 2009

Over the last 2 week, how often have you been bothered by the following problems?

	Not at all	Several days	More than half the days	Nearly every day
1. Feeling Nervous, anxious or on edge?	0	1	2	3
2. Not being able to stop or control worrying?	0	1	2	3
3. Little interest or please in doing things?	0	1	2	3
4. Feeling down, depressed, or hopeless?	0	1	2	3

Emotional Responses of Athletes to Injury Questionnaire Item (Smith et al., 1990)

1. If 0% is no recovery, what percentage of recovery have you made to your pre-injury status: (ERAIQ)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Disablement in the Physically Active Scale (Vela & Denegar, 2010a)

Instructions: Please answer each statement with one response by circling the number that most closely describes your problem(s) within the past **24 hours**. Each problem has possible descriptions under each. Not all descriptors may apply to you but are given as common examples.

KEY

1- No problem
2- I have the problem(s), but it does not affect me
3- The problem(s) slightly affects me
4- The problems(s) moderately affects me
5- The problem(s) severely affects me

	No problem	**Does not affect**	**Slight**	**Mode rate**	**Sev ere**
Pain – "Do I have pain?"	1	2	3	4	5
Motion – "Do I have impaired motion?" Ex. Decreased range/ease of motion, flexibility, and/or increased stiffness	1	2	3	4	5
Muscular Functioning – "Do I have impaired muscle function?" Ex. Decreased range/ease of motion, flexibility, and/or increased stiffness	1	2	3	4	5
Stability – "Do I have impaired stability?" Ex. The injured area feels loose, gives out, or gives way	1	2	3	4	5
Changing Directions – "Do I have difficulty with changing directions in activity?" Ex. Twisting, turning, starting/stopping, cutting, pivoting	1	2	3	4	5
Daily Activities – "Do I have difficulty with daily actions that I would normally do?" Ex. Walking, squatting, getting up, lifting, carrying, bending over, reaching, and going up/down stairs	1	2	3	4	5
Maintaining Positions – "Do I have difficulty maintaining the same position for a long period of time?"					

Ex. Standing, sitting, sleeping	1	2	3	4	5
Skill performance – "Do I have difficulties with performing skills that are required for physical activity?"					
Ex. Running, jumping, & kicking	1	2	3	4	5
Ex. Coordination, agility precision & balance	1	2	3	4	5
Overall fitness – "Do I have difficulty maintaining my fitness level?"					
Ex. Conditioning, weight lifting & cardiovascular endurance	1	2	3	4	5
Participation in activities - "Do I have difficulty with participating in activities?"					
Ex. Participating in leisure activities, hobbies, and games	1	2	3	4	5
Ex. Participating in my sport(s) of preference	1	2	3	4	5
Well-Being – "Do I have difficulties with the following…?"					
1) Increased uncertainty, stress, pressure, and/or anxiety	1	2	3	4	5
2) Altered relationships with team, friends, and/or colleagues	1	2	3	4	5
3) Decreased overall energy	1	2	3	4	5
4) Changes in my mood and/or increased frustration	1	2	3	4	5

Appendix C

IRB Approval Form

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Human Research Protection Program
Office of the Vice President for Research

D528 Mayo Memorial Building
420 Delaware Street S.E.
MMC 820
Minneapolis, MN 55455

Office: 612-626-5654
Fax: 612-626-6061
E-mail: irb@umn.edu or ibc@umn.edu
Website: http://research.umn.edu/subjects/

07/16/2013

Hayley C Russell

RE: "Psychological predictors of return to play after ACL injury."
IRB Code Number: **1306P36042**

Dear Dr. Russell:

The Institutional Review Board (IRB) received your response to its stipulations. Since this information satisfies the federal criteria for approval at 45CFR46.111 and the requirements set by the IRB, final approval for the project is noted in our files. Upon receipt of this letter, you may begin your research.

IRB approval of this study includes the parental consent form, assent form, and HIPAA form, all received July 15, 2013; and the adult consent form and recruitment letter, both received June 25, 2013.

The IRB would like to stress that subjects who go through the consent process are considered enrolled participants and are counted toward the total number of subjects, even if they have no further participation in the study. Please keep this in mind when calculating the number of subjects you request. This study is currently approved for 150 subjects. If you desire an increase in the number of approved subjects, you will need to make a formal request to the IRB.

For your records and for grant certification purposes, the approval date for the referenced project is June 26, 2013 and the Assurance of Compliance number is FWA00000312 (Fairview Health Systems Research FWA00000325, Gillette Children's Specialty Healthcare FWA00004003). Research projects are subject to continuing review and renewal; approval will expire one year from that date. You will receive a report form two months before the expiration date. If you would like us to send certification of approval to a funding agency, please tell us the name and address of your contact person at the agency.

As Principal Investigator of this project, you are required by federal regulations to inform the IRB of any proposed changes in your research that will affect human subjects. Changes should not be initiated until written IRB approval is received. Unanticipated problems or serious unexpected adverse events should be reported to the IRB as they occur.

The IRB wishes you success with this research. If you have questions, please call the IRB office at 612-626-5654.

Sincerely,

Christina Dobrovolny, CIP
Research Compliance Supervisor
CD/ks

CC: Elizabeth Arendt, Diane Wiese-Bjornstal

Appendix D

Study Information Letter

UNIVERSITY OF MINNESOTA
Twin Cities Campus

School of Kinesiology
College of Education and Human Development

Cooke Hall
1900 University Avenue SE
Minneapolis, MN 55455
(612) 590-7401
Russe494@umn.edu
www.cehd.umn.edu/kin

You have been identified as a potential participant in a research study conducted by a PhD student (under the supervision of a professor and orthopedic surgeon) at the University of Minnesota in conjunction with TRIA Orthopaedic Center. Participation in this study will involve 2 parts. The first will be the completion of a series of questionnaires about your experience with ACL injuries. These questionnaires will be completed online three times over the next 9 months and will take about 20 minutes to complete. You will be asked to answer questions about things like how you feel about returning to activity after your injury and how much you like sport and physical activity. The second part of this study will involve giving permission for the researcher to access information from your medical chart. The only information that will be accessed would be the date of your surgery and scores on assessments of your knee such as strength and range of motion. No other medical information of any kind will be accessed. Participants in this study will be compensated for their time with a total of $40 in gift cards.

In order to maintain confidentiality you will only be contacted about this study if you choose to provide your contact information below.

Thank you for your consideration,

Hayley Russell
PhD Candidate
Department of Kinesiology
University of Minnesota

By providing contact information below I consent to be contacted by the researcher, Hayley Russell, about participation in this study. It does not consent to participation in the study.

Please provide your **preferred** method of contact

Name: _____
Telephone: _____
Email: _____

☐ I prefer not to be contacted for this study.

School of Kinesiology

Appendix E

Recruitment Email

Dear ,

My name is Hayley Russell and I am a PhD student in the department of Kinesiology at the University of Minnesota conducting a research study on ACL injuries. I received your contact information from TRIA. I would like to thank you for agreeing to be contacted for this study. If you are still interested in participating in the study I need a little more information from you. Once I receive this information I will mail you an informed consent letter containing additional information about participation.

Please indicate if you are completing this information for yourself or your child.

1. What is your date of birth?
2. What was/is the date of your ACL surgery?
3. Is this your first ACL surgery?
4. Did you tear your ACL while playing a sport or participating in physical activity?
5. Do you intend to return to sport or physical activity after you recover from your injury?
6. Please provide your mailing address.

Thank you again for your interest in this study,

Hayley

Appendix F

Adult Informed Consent

CONSENT FORM

Predictors of return to play after ACL injury

You are invited to be in a research study looking at the psychological and physical factors that are associated with returning to sport after ACL injury. You were selected as a possible participant because you have undergone ACL reconstruction surgery in the last 4 months. We ask that you read this form carefully and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Hayley Russell a Ph.D. student in the department of Kinesiology at the University of Minnesota under the supervision of Dr. Wiese-Bjornstal in the department of Kinesiology and Dr. Elizabeth Arendt in the department Orthopaedic Surgery at the University of Minnesota

Background Information

The purpose of this study is to determine what thoughts, feelings, behaviors and physical factors impact an athlete's return to sport after they undergo ACL reconstruction surgery.

Procedures:

If you agree that you be in this study, we would ask you to do the following things:
We will ask you to complete a series of questionnaires online. These questionnaires will take about 20 minutes to complete. We will ask you to complete them 3 different times in the next 9 months. We will also ask you to give us permission to access certain information from your medical chart at TRIA this includes surgery date, surgery type, strength, joint laxity, range of motion and functional testing at 4, 6, and 9 months after surgery.

Risks and Benefits of being in the Study

The study has several risks: First, is the questionnaires take about 20 minutes to complete therefore you may get bored while completing them. Second, although it is unlikely you may experience some emotional distress while thinking about your knee injury, recovery and return to sport.

The benefits of this study are that it can help us better understand the psychological and physical factors most important to address when treating athletes with ACL injuries. There are no direct benefits of participating in this study.

Compensation:

You will receive payment of $40 in Target gift cards if you complete all three sets of questionnaires. You will receive a $10 gift card by mail after you complete the first set of

questionnaires, another $10 gift card after you complete the second set of questionnaires and a $20 gift card after you complete the third set of questionnaires.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify you. Research records will be stored securely in a locked cabinet in a locked office at the University of Minnesota and only researchers working on this study will have access to the records. Online study data will be encrypted according to current University policy for protection of confidentiality.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not you can participate will not affect you current or future relations with the University of Minnesota or TRIA. If you decide you will participate, you are free to not answer any questions or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are: Hayley Russell and Dr. Wiese-Bjornstal. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Hayley 612-590-7401 or russe494@umn.edu or Dr. Wiese-Bjornstal at 612-625-6580 or dwiese@umn.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:_____Date: _____

Signature of
Investigator_____Date:_____

Appendix G

Child Informed Consent

CONSENT FORM
Predictors of return to play after ACL injury

Your child is invited to be in a research study looking at the psychological and physical factors that are associated with returning to sport after ACL injury. Your child was selected as a possible participant because he/she has undergone ACL reconstruction surgery in the last 4 months. We ask that you read this form carefully and ask any questions you may have before agreeing to be in this study.

This study is being conducted by: Hayley Russell a Ph.D. student in the department of Kinesiology at the University of Minnesota under the supervision of Dr. Wiese-Bjornstal in the department of Kinesiology and Dr. Elizabeth Arendt in the department Orthopaedic Surgery at the University of Minnesota

Background Information

The purpose of this study is to determine what thoughts, feelings, behaviors and physical factors impact an athlete's return to sport after they undergo ACL reconstruction surgery.

Procedures:

If you agree that your child can be in this study, we would ask you to do the following things:
We will ask your child to complete a series of questionnaires online. These questionnaires will take about 20 minutes to complete. We will ask your child to complete them 3 different times in the next 9 months. We will also ask you to give us permission to access certain information from your child's medical chart at TRIA this includes surgery date, surgery type, strength, joint laxity, range of motion and functional testing at 4, 6, and 9 months after surgery.

Risks and Benefits of being in the Study

The study has several risks: first, is the questionnaires take about 20 minutes to complete therefore your child may get bored while completing them. Second, although it is unlikely your child may experience some emotional distress while thinking about their knee injury, recovery and return to sport.

The benefits of this study are that it can help us better understand the psychological and physical factors most important to address when treating athletes with ACL injuries. There are no direct benefits of participating in this study for your child.

Compensation:

Your child will receive payment of $40 in Target gift cards if he/she completes all three sets of questionnaires. Your child will receive a $10 gift card by mail after he/she completes the first set of questionnaires, another $10 gift card after he/she completes the second set of questionnaires and a $20 gift card after he/she completes the third set of questionnaires.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify your child. Research records will be stored securely in a locked cabinet in a locked office at the University of Minnesota and only researchers working on this study will have access to the records. Online study data will be encrypted according to current University policy for protection of confidentiality.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not your child can participate will not affect your or your child's current or future relations with the University of Minnesota or TRIA. If you decide your child can participate, he/she is free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are: Hayley Russell and Dr. Wiese-Bjornstal. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Hayley 612-590-7401 or russe494@umn.edu or Dr. Wiese-Bjornstal at 612-625-6580 or dwiese@umn.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:_____Date: _____

Signature of Investigator_____Date: _____

Appendix H

Assent Form

Assent Form

Knee Injury Study

We are asking if you are willing to answer some questions about your knee injury and surgery because we are trying to learn about how athletes think and feel about knee surgeries and returning to sport. Because you tore~~n~~ your anterior cruciate ligament (ACL) while you were playing a sport, we are asking you to be in our study. We know people think and feel differently about tearing their ACL and having to have surgery and that this can impact how they feel about returning to playing a sport so we would like to know about your experience.

If you agree to be in this study, we will ask you to fill out questionnaires online 3 times after your surgery. These questionnaires will take about 20 minutes to answer. There are no right or wrong answers. We will also be asking your doctor to give us some information about your knee recovery such as how strong your legs is.

You may find the questionnaires boring to complete. There are no direct benefits to you for participating in this study other than that you will receive $40 in gift cards to Target for participating.

We will not share the answers you any of the questions or your knee recovery information with anyone else – not your parents, coaches, or doctors.

Being in this study is completely up to you. If you decide to be in our study and then change your mind you can stop answering the questionnaires without any punishment.

Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don't want to be in this study don't sign. Remember, being in this study is up to you and no one will be mad or upset with you if you don't sign or even if you change your mind later.

Signature of participant_____

Signature of person explaining study_____

Date_____

Appendix I

HIPPA Authorization Form

HIPAA[1] AUTHORIZATION TO USE AND DISCLOSE INDIVIDUAL HEALTH INFORMATION FOR RESEARCH PURPOSES

1. Purpose. As a research participant, I authorize Hayley Russell, supervisor Dr. Wiese-Bjornstal and Dr. Elizabeth Arendt and the researcher's staff to use and disclose my individual health information for the purpose of conducting the research project entitled Psychological and physical predictors of return to play after ACL surgery, [IRB subject code: 1306P36042].

2. Individual Health Information to be Used or Disclosed. My individual health information that may be used or disclosed to conduct this research includes: surgery date, surgery type, strength, range of motion joint laxiety and functional testing data.

3. Parties Who May Disclose My Individual Health Information.
The researcher and the researcher's staff may obtain my individual health information from other healthcare providers, such as laboratories, which are a part of this research, as well as healthcare providers that are not part of this research (other doctors, hospitals and/or clinics) for the purposes of carrying out this research study. I authorize these parties to disclose my individual health information to the researcher and the researcher's staff for the purposes of carrying out this research study.

4. Parties Who May Receive or Use My Individual Health Information. The individual health information disclosed by parties in item 3 and information disclosed by me during the course of the research may be received and used by Hayley Russell and the researcher's staff and Dr. Diane Wiese-Bjornstal, and Dr. Elizabeth Arendt . [OPTIONAL: Also, if I receive compensation for participating in this study, identifying information about me may be used or disclosed as necessary to provide compensation.]

5. Right to Refuse to Sign this Authorization. I do not have to sign this Authorization. If I decide not to sign the Authorization, I may not be allowed to participate in this study or receive any research related treatment that is provided through the study. However, my decision not to sign this authorization will not affect any other treatment, payment, or enrollment in health plans or eligibility for benefits.

6. Right to Revoke. I can change my mind and withdraw this authorization at any time by sending a written notice to Hayley Russell at Cooke Hall 1900 University Ave., University of Minnesota, Minneapolis, MN, 55455 to inform the researcher of my decision. If I withdraw this authorization, the researcher may only use and disclose the protected health information already collected for this research study. No further health information about me will be collected by or disclosed to the researcher for this study.

7. Potential for Re-disclosure. Once my health information is disclosed under this authorization, there is a potential that it will be re-disclosed outside this study and no longer covered by this authorization. However, the research team and the University's Institutional Review Board (the committee that reviews studies to be sure that the rights and safety of study participants are protected) are very careful to protect your privacy and limit the disclosure of identifying information about you.

[1] HIPAA is the Health Insurance Portability and Accountability Act of 1996, a federal law related to privacy of health information.

7A. Also, there are other laws that may require my individual health information to be disclosed for public purposes. Examples include potential disclosures if required for mandated reporting of abuse or neglect, judicial proceedings, health oversight activities and public health measures.

8. [Optional Item] **Suspension of Access**. I may not be allowed to review the information collected for this study, including information recorded in my medical record, until after the study is completed. When the study is over, I will have the right to access the information again.

This authorization does not have an expiration date.

I am the research participant or personal representative authorized to act on behalf of the participant.

I have read this information, and I will receive a copy of this authorization form after it is signed.

_____	_____
signature of research participant or research participant's personal representative	date
_____	_____
printed name of research participant or research participant's personal representative	description of personal representative's authority to act on behalf of the research participant