

https://dspace.org/

Compliance with Rehabilitation and Return-to-Play Assessments in Patients After Anterior Cruciate Ligament Reconstruction

Alexander, Laine

2024
University of the Witwatersrand, Johannesburg
https://hdl.handle.net/10539/47992

Alexander, Laine . (2024). Compliance with Rehabilitation and Return-to-Play Assessments in Patients After Anterior Cruciate Ligament Reconstruction [Master`s dissertation, University of the Witwatersrand, Johannesburg]. WIReDSpace. https://hdl.handle.net/10539/47992

Downloaded from a DSpace repository. https://dspace.org/

COMPLIANCE WITH REHABILITATION AND RETURN TO PLAY ASSESSMENTS IN PATIENTS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION





A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine.

Johannesburg, 2024

Principle Investigator

Dr Laine Alexander

MBChB (UCT), MSc SEM (Stel), DipPEC (SA)

Student number: 2527848

Research Supervisor

Dr Brad Gelbart

MBBCh (Wits), DA(SA), FC Orth (SA), MMed Orth Surg (Wits)

Co-supervisor

Dr Brenda Milner

PhD (Wits)

Table of contents

Declaration…… iii.

Acknowledgements……... iv.

Abstract……. v.

Nomenclature…… vii.

List of figures……... viii.

List of tables……. ix.

1. INTRODUCTION / LITERATURE REVIEW……. 1.

2. STUDY AIM AND OBJECTIVES……... 9.

3. METHODOLOGY…… 10.

4. RESULTS…….. 15.

5. DISCUSSION…… 29.

6. LIMITATIONS…….. 41.

7. CONCLUSION…….. 43.

REFERENCES……... 44.

APPENDICES…… 47.

Appendix A: Research Questionnaire…… 47.

Appendix B: Participant information and informed consent……. 51.

Appendix C: Tegner activity score……. 53.

Appendix D: Lysholm Knee Scoring Scale……... 54.

Appendix E: WITS Human Research Ethics clearance certificate…..……..... 55.

Appendix F: Netcare Linksfield Hospital approval……... 56.

Appendix G: WITS Research Protocol Committee approval…… 57.

Declaration

I, Laine Alexander, declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the speciality of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



……

6 December 2024

……

Johannesburg, RSA

Acknowledgments

I would like to acknowledge my supervisors Dr Gelbart and Dr Milner for their motivation, guidance, and contributions to this project. In addition, I would like to express my sincere gratitude to each patient who was willing to participate in this study.

Abstract

Compliance with rehabilitation and return to play assessments in patients after anterior cruciate ligament reconstruction.

Background

Anterior cruciate ligament reconstructions (ACLR) are commonly performed but there is no evidence available on compliance with rehabilitation protocols or the completion of an objective return to sports assessments prior to return to play (RTP) and what effect this may have on ACLR outcomes in our environment. The aim of this study was to assess patient compliance with a rehabilitation programme and return to sports assessment in patients who underwent ACLR and related surgery. The objectives were to: 1) determine the level of compliance with a rehabilitation programme and return to sports assessment, 2) identify the barriers to compliance and motivating factors for increased compliance in these patients, 3) analyse whether certain patient characteristics affect compliance level, 4) describe and compare the RTP rates, re-injury rates and secondary surgery rates between completion of rehabilitation programme and return to play assessment groups.

Design

The study was conducted using a retrospective patient record review with a prospective recall via an online questionnaire.

Results

Eighty percent of our participants completed their rehabilitation programme. More than half of the sample completed less than 6 months of their programme and only sixty percent of patients completed a RTP assessment. Most of our participants were motivated by their own desire to reach pre-injury level of activity and by their physiotherapist. Time constraints and lack of funding were cited as the most frequent barriers to rehabilitation.

Our RTP rate was calculated to be 90% and when comparing those who returned to ‘some form of sport and the mean time to RTP was 8.88 months. The overall post-surgery Lysholm score

in this study was 91.02. Overall, the re-injury rates were low. We identified that younger individuals, females and those who had a higher pre-injury Tegner score were more likely to complete more months of their rehab programme. Similarly, younger, and competitive athletes have a higher chance of completing their RTP assessment. We found that RTP rates, re-injury and secondary surgery were not associated with completion of the rehabilitation programme. Subsequent injury of the other knee and RTP rates were associated with completion of the RTP assessment.

Conclusion

This study is the first to document the compliance with rehabilitation programmes and the completion of return to sports assessments prior to RTP and what effect this may have on ACLR outcomes in the South African context. We have endeavoured to identify barriers to compliance and motivating factors for increased compliance in our patients who have undergone ACLR surgery. The study reviewed multiple return to play variables and identified factors which predict increased compliance.

Key Words

ACLR, Rehabilitation, Compliance, Outcomes

Nomenclature

ACL	Anterior cruciate ligament
ACLR	Anterior cruciate ligament reconstruction
BMI	Body mass index
BML	Bone marrow lesion
IKDC	International Knee Documentation Committee
IQR	Interquartile range
KOOS-QoL	Knee Injury and Osteoarthritis Outcome Score for quality of life
LEAP	Lower Extremity Assessment Protocol
MCL	Medial collateral ligament
OA	Osteoarthritis
ROM	Range of motion
RTM	Return to match play
RTP	Return to play
RTT	Return to training
SF-36	Short Form 36
SD	Standard deviation
USA	United States of America

List of figures

Figure 4.1 Study sample…….. 15.

Figure 4.2 Age of participants……. 17.

Figure 4.3 BMI of participants…… 17.

Figure 4.4 Completion of the rehabilitation programme……. 18.

Figure 4.5 Rehabilitation programme: Motivating factors for increased compliance…. 18.

Figure 4.6 Barriers to completing their rehabilitation programme…….. 19.

Figure 4.7 Level of compliance: Number of months of their rehabilitation programme completed…….…….. 20.

Figure 4.8 Motivating factors for completion of the RTP assessment…… 21.

Figure 4.9 Barriers to completing the RTP assessment……... 21.

Figure 4.10 Months taken to return to some form of sport…… 22.

Figure 4.11 Further injury to the same knee…….. 23.

Figure 4.12 Further surgery to the same knee……... 24.

List of tables

Table 3.1 Data analysis plan……... 13.

Table 4.1 Participant biodata, level of compliance, return to sport variables and PROM scores……. 16.

Table 4.2 Linear regression model to determine predictors of number of rehabilitation programme months completed…… 25.

Table 4.3 Pre-op Tegner for completion of rehabilitation programme groups…….. 25.

Table 4.4 Logistic regression model analysing predictors of completing a RTP assessment……... 26.

Table 4.5 Pre-op & post-op Tegner for completion of RTP assessment groups……..... 27.

Table 4.6 Comparing completion of rehabilitation programme groups……. 27.

Table 4.7 Comparing completion of RTP assessment groups…… 28.

1. Literature review

1.1. Background

Anterior cruciate ligament (ACL) injuries are serious and potentially career-ending for athletes. (1) They are prevalent in individuals between the ages of 15-40 years, who participate in sports that involve jumping, sudden decelerations, single-leg landing and cutting manoeuvres such as basketball and soccer. (2,3)Approximately 250 000 ACL tears occur annually in the United States of America (USA). (2) Injury may result from a non-contact pivoting motion resulting in a knee that is externally rotated, slightly flexed and in valgus or a direct blow to the lateral aspect of the knee. (3) Females are more likely to sustain ACL tears, attributed to an array of biomechanical and neuromuscular activation differences (e.g. quadriceps muscle dominant). (3)

The ACL provides up to 90% of the stability to anterior translation of the tibia and tears lead to anterior and lateral rotatory instability of the knee joint. (2,3) Most ACL tears occur in combination with other associated injuries including but not limited to: meniscal tears, medial collateral ligament (MCL) injuries and bone marrow lesions (BMLs). (4)

1.2. Treatment

Most ACL tears are in-substance tears precluding primary repair and thus anterior cruciate ligament reconstruction (ACLR) is the surgical treatment of choice. (1,2) Flagg et al. (2019) estimates that over 120 000 anterior cruciate ligament reconstructions (ACLRs) are performed yearly in the USA. (3) The majority of ACLRs are performed arthroscopically assisted to facilitate tunnel placement of the graft. Autogenous bone-patellar tendon-bone graft or semitendinosus with gracilis quadruple tendon bundle grafts are used and anchored with interference screws, staples or sutures tied around fixation posts. The presence and extent of associated injuries will affect the way in which the ACL injury is managed and rehabilitated. For example, cartilage and bone marrow lesions are frequently associated with poorer outcomes post ACLR. (3–5)

1.3. Rehabilitation

The success of an ACLR is strongly linked to the patient's compliance to post-operative rehabilitation. Rehabilitation programmes have accelerated greatly over the past few decades, in part due to the concept of complete immobilisation falling out of favour. Protected weight bearing has decreased post-operative joint stiffness rates and allowed earlier progression to strength exercises. (4) Rehabilitation goals include regaining the patient's strength and proprioception and improving pain, range of motion and neuromuscular control all whilst the soft tissues heal and remodel. Core stability and balance exercises also have integral roles in recovery. (4) Rehabilitation programmes need not be clinically supervised especially in resource-limited settings. In fact, with thorough patient education, some home-based rehabilitation programmes have equal outcomes when compared to standard physiotherapy programmes. (6)

A typical rehabilitation programme is divided into four phases: 1) In the first two weeks, the patient progresses from partial to full weight bearing with the goal of 0-100° flexion range of motion (ROM). Full passive extension must be encouraged. 2) Between 2-12 weeks, knee flexion should reach 130°, the swelling should have subsided, and the patient should be able to walk unrestricted. Closed chain exercises, eccentric and isometric quadriceps and hamstring contractions can commence. 3) By 3-6 months, full ROM and strength should be restored and the athlete strives to return to jogging and agility drills. 4) Finally, between 6-12 months progressive return to sport can occur which commences with restricted training and ultimately progressing to match play. These time frames should be individualised and should take into consideration the extent of damage, patient adherence, extent of knee stiffness and the patient's functional goals. (4) Open chain quadriceps strengthening should be avoided for at least the first 3 months post injury.

1.4. ACLR outcomes

Numerous outcome measures used to determine ACLR success have been published in the literature. Common measures include: return to play (RTP), including the layoff duration and rate of return to pre-injury sport level, self-reported knee function and the re-injury or re-rupture rate. (4,7)

Return to play

A major goal of ACL treatment is to return the patient to a pre-injury activity level in the shortest time possible whilst mitigating undue risk of re-injury (8). Therefore, RTP can be used as a surrogate in measuring ACLR outcomes. The return to play continuum includes return to training (RTT) and return to match play (RTM). (9)

Reports of RTP rates do not use a consistent definition and therefore should be interpreted with caution.(4) Many articles do not state whether their RTP end-point was a RTT or RTM and whether this match play level was truly at an equivalent pre-injury level (e.g. number of minutes played or goals scored compared to the pre-injury level). (1,7) In addition, some authors will publish a return rate measured at the one-year post surgery mark whilst others measure this rate after three or five years or evaluate how many players are still participating after these time intervals i.e. subsequent career length. Finally, RTM is often associated with non-medical factors. For example, participation also depends on the athletes' form, player position, period of the season and his or her relationship with the coach and team captain. RTT is perhaps less confounded by these factors. (7)

We thus see a large variation of RTP rates published in the literature. A 2016 prospective study on football players revealed high initial RTP rates of 90% (at one year) but rates of 65% at top level and 85% to 'some form of sport' at three years post-injury. Similar figures with respect to initial rates and at three years were published by Webster et al. (10) The same author published a report on soccer players in 2011 which showed an initial RTP rate of 94% after ACLR. (10) A meta-analysis from 2014 found that 81% of patients returned to some form of sport, 65% to their pre-injury level and 55% returned to competitive level sport. (11)

The timing of return to sport is a complex process which should be facilitated by a multi-disciplinary team. (7) It is dependent of several factors including knee stability, neuromotor function, the nature of the sport, the physiotherapist, biokineticist and coach's opinions and, the psychology of the athlete. (4) At one end of the spectrum, some authors advocate waiting two years, until such a stage that complete biological and functional recovery is achieved before returning to play. Although this may decrease the risk of subsequent injury, this precautionary delay may have a serious impact on the athlete's immediate and long-term career. (8) This is contrasted by Webster et al. (2021) who found no difference in the incidence of graft rupture

or re-injury if athletes were instructed to wait more than 12 months before returning to sport. Despite these results, the authors do not advocate for earlier returns and comment that the causes of re-injury are multi-factorial and further research is needed. (10)

Layoff times are declining especially in elite sports. This is thought to be due to early diagnostics, swift referral to high-volume surgeons, daily supervised rehabilitation and huge financial incentives to resume playing. (7)

Return to play criteria

Traditionally, RTP guidelines have been based on patients' time after surgery. (9) In fact since 1990, time has represented 50% of the total RTP criteria reported in the published research. (9) It is now widely accepted that athletes should pass a series of functional tests that replicate sport-specific activities and time should no longer be used in isolation. (9)

However, there is considerable debate as to what should be evaluated in these assessments. (3,12) Objective performance testing forms part of the decision-making process and supplements the practitioner's clinical examinations. (9,12) A simple and practical test is the single-leg hop test. This evaluates the extent of dynamic valgus occurring at the knee which has been shown to increase the risk of ipsilateral re-rupture and contralateral rupture post-reconstruction. (7,11)

Although not validated for RTP post ACLR, isokinetic testing can be used to evaluate muscle strength. This is also referred to as impairment testing. (4,13) Muscular deficits after ACLR are mainly graft-related and may persist for up to two years. (4) A computer assisted machine called an isokinetic dynamometer or *Biodex* is used to assess the patient's isokinetic strength in flexion and extension. There is currently no standardised isokinetic protocol following ACLR, but examples of the common tests include: concentric/concentric mode of contraction, angular velocity of 60°/s for 3 – 5 repetitions and strength limb symmetry index scores. Testing is performed on the uninvolved and involved limb and scores are used to calculated symmetry percentages by dividing the involved limb (peak torque normalised for body weight) by the uninvolved limb. (4,13)

There are a multitude of tests described in the literature however, the predictive validity of most RTP tests is unknown. (9) Clearance criteria published by Kyritsis et al. (2016) are an example of frequently used tests: (14)

- Isokinetic testing at 60°/180°/300° including a hamstring to quadriceps ratio of <10% at 60°
- On field sports specific rehabilitation completed
- Hop test (single/triple/crossover) with limb symmetry index scores >90% (9)
- Running T-test <11s

Another example is the Lower Extremity Assessment Protocol (LEAP) which is a battery of functional assessments and subjective questionnaires used to characterise a patient's function after lower extremity injury. (12) The protocol consists of:

- Patient reported outcomes: The International Knee Documentation Committee (IKDC) and Tegner activity scale
- Knee extensor peak torque and symmetry >90%
- Knee flexor peak torque and symmetry

Objective assessments can also be used for more than clearance decisions. They can also be used for periodic evaluation of rehabilitation benchmarks ensuring that patients are meeting their treatment goals. These assessments should be repeated at two monthly intervals to appreciate meaningful clinical improvements particularly for strength and symmetry testing. (12)

A 2016 consensus statement on RTP provides the following recommendations to guide the choice of RTP tests: "*1) use a battery of tests, 2) choose open tasks over closed tasks, 3) include tests with reactive decision-making elements, 4) assess psychological readiness, and 5) monitor internal and external workload. This should be combined with a minimum 9-month time criterion*." (9)

Ultimately there needs to be greater focus on the athlete and the sport. There is a dominance of impairment-based measures in comparison to activity and contextual factors. Unfortunately,

activity and sport-based tests can be more difficult to standardise and may require complex equipment. However, it is imperative that practitioners get a sense of the athletes' ability to cope with the demands of his or her sport before allowing them to RTP. Further research into the development of valid, accurate and sports-specific tests of participation for athletes is certainly needed. (9)

Walker et al. (2020) analysed over 36 publications focused on ACL rehabilitation adherence and found that patients perceived the *"therapeutic relationship, interaction with family or friends, self-motivation, fear of re-injury, lack of time and interpersonal comparison as the most common barriers to and facilitators of rehabilitation."* (15) A subsequent cross-sectional survey showed that a '*good relationship with your rehabilitation provider'* was the most important factor in facilitating rehabilitation. (15) The same study group identified 5 themes, consistently perceived by patients as the most important factors which affected their rehabilitation journey namely: "*1) the rehabilitation service e.g. access to care, 2) rehabilitation characteristics e.g. goal setting, 3) psychological e.g. fear of re-injury, 4) physiological e.g. age or knee pain, 5) interaction with others e.g. family or coach."* (15)

Self-reported knee function

Historically ACLR outcomes have been obtained by an observer using a scoring scale such as the Lysholm Knee Scoring Scale, Cincinnati Knee Ligament Rating Scale (CKRS) or the IKDC. (9) A study by Roos et al. (2001) found that surgeons tend to overestimate function and underestimate patient symptoms and consequently the use of self-administered questionnaires is now preferred. (16)

Quality of life (QoL) scores are frequently utilised in the literature to assess ACLR success. The Knee Injury and Osteoarthritis Outcome Score – QOL (KOOS-QoL) and the Short Form 36 (SF-36) domain scores are two examples. Modern modifications of the CKRS, Lysholm Knee Scoring Scale and IKDC now include ratings of the patient's perception of knee function, qualify as patient reported outcome measures and have been shown to be valid and reliable. (9)

Re-injury and graft rupture rates

Re-injury rates can also be used as a measure of ACLR success. However, studies on subsequent ACL rupture (graft and contralateral knee) after ACLR reconstruction are scarce. (1) Most reviews suggest that the risk of graft rupture is highest within the first 12 months. (2) Younger patients are at an increased risk for ACL graft rupture and contralateral injury and rates as high as 33% (RTP within one year) have been reported. (2,10)

The causes of graft failure can vary. Many failures are attributed to surgical technique, most notably, tunnel malposition but recent evidence has shown that traumatic re-injury is now the leading cause (24% *versus* 32%, respectively). (2) Other technical factors which may contribute to graft failures include: over or under-tensioning, missed diagnosis of concomitant injuries (leading to graft overload) and graft impingement. (2) Early failures are usually due to infection, fixation loss or aggressive physical therapy (e.g. open chain exercises) whereas those occurring more than one-year post-surgery are usually due to trauma. (2)

Kyritsis et al. (2016) reported a four times greater risk of graft rupture if athletes returned to sport before passing their six discharge criteria. In addition, a lower hamstring to quadriceps ratio was associated with an increased risk of graft rupture. (2,14) A study by Della Villa et al. (2021) found the second ACL injury rate (including the contralateral knee) after RTT to be 17.8% at four-year follow-up. Athletes whose index injury was a non-contact ACL tear were most at risk for a second ACL injury and graft type was not associated with increased risk of second ACL injury. (2)

As discussed, RTP statistics, re-injury rates and patient report outcome scores can be used effectively to measure the success of ACLR. It is clear that good quality rehabilitation is paramount to recovery and poor patient adherence will lead to poor outcomes. We have noted that the variables involved in RTP decision-making are multifactorial and it seems intuitive that a time-based protocol combined with an objective assessment is the answer but unfortunately, there is still no validated battery of tests that uniformly predicts safe and consistent RTP. Whether these assessments require sophisticated equipment such as *Biodex* machines or merely a tape measure and some beacons, the fact remains that re-injury is far higher in individuals who return to sport prior to completing some form of a clearance test. (4)

There is a paucity of literature available on this subject in the South African context. We see many patients with ACL injuries who undergo surgery but there is no evidence available on compliance with rehabilitation protocols or the completion of an objective return to sports assessments prior to RTP and what effect this may have on ACLR outcomes in our environment.

2. Study Aim and Objectives

Hypothesis: All patients who underwent ACLR at our centres completed their rehabilitation programme and successfully passed an objective return to sport clearance test prior to RTP.

2.1. Aim:

The aim of this study was to assess patient compliance with a rehabilitation programme and return to sports assessment in patients who underwent ACLR and related surgery.

2.2. Objectives:

1) To determine the level of compliance with a rehabilitation programme and return to sports assessment in our cohort.
2) To identify the barriers to compliance and motivating factors for increased compliance in these patients.
3) To analyse whether the following patient characteristics affect compliance level: age, gender, or prior sporting level.
4) To describe and compare the RTP rates, re-injury rates and secondary surgery rates between patients who completed a rehabilitation programme and return to play assessment versus those who did not.

3. Methodology

3.1. Study design and overview

A retrospective analysis on a cohort of patients who underwent anterior cruciate ligament reconstruction and related surgery at the *Linksfield Orthopaedic Sports and Rehabilitation Centre Johannesburg* and *Centre for Sports Medicine and Orthopaedics in Rosebank, South Africa* between 01/01/2016 and 31/12/2021 (a six-year period) was performed. The study was conducted using a retrospective patient record review with a prospective recall via an online questionnaire. Consent was obtained from participants for their de-identified data to be used for research purposes. No individuals were actively recruited for the study.

3.2. Data Source

Data was obtained from:

1) Patient clinical records
2) A *REDCap* electronic questionnaire (Appendix A)

3.3. Inclusion and exclusion criteria

Inclusion criteria:

Eligible participants included patients 18 years or older who underwent ACLR (a single ligament) and related surgery with or without associated meniscus and cartilage injury, using a combined semitendinosus and Gracilis autograft, without complications. A minimum follow-up of 18 months post ACLR was required.

The surgery must have been conducted by a board-certified, fellowship trained sports orthopaedic surgeon. All participants followed the same post-operative rehabilitation guidelines and were advised to perform a return to sports assessment prior to RTP.

Exclusion criteria:

Eligible participants who could not be contacted telephonically or via email were excluded from the study. Patients were excluded if they had a multi-ligament knee injury, if they had lower extremity surgery prior to their ACLR, a surgical complication or graft failure prior to their index ACLR surgery. Patients who were unable to attend a physio or biokinetics programme due to other health conditions were also excluded.

3.4. Study site

All data were collected from patients who underwent surgery at the *Linksfield Orthopaedic Sports and Rehabilitation Centre Johannesburg, South Africa* and *Centre for Sports Medicine and Orthopaedics in Rosebank, South Africa.*

3.5. Sample size calculation

The sample size was determined by the primary endpoint of RTP rate at one-year post surgery. Using STATA Version 14 statistical software, the confidence interval was taken at 95% and the expected sample error of 5% was used with a power of 80%. The sample size calculation was derived using a Score Z test. In a recent meta-analysis, 81% of patients returned to some form of sport. (11) Although 81% returned to some form of sport, we expect that 91% of the sample would have completed their rehabilitation programme, even if they did not return to play and thus, this value was used as the hypothesised figure in our study. With these values in mind, the sample size required was calculated to be 102.

3.6. Data collection

Patient records were used to evaluate personal details, past medical and surgical history, surgical findings, post-operative clinical findings and strength and functional assessments performed by qualified Biokineticists (Bio) at the practice during the rehabilitation and RTP testing phases.

A *REDCap* questionnaire was sent to all participants via e-mail. A patient information sheet and consent form (Appendix B) was built into the cover page of the questionnaire. The questionnaire included questions evaluating personal details (age, gender, height, and weight), past medical history and past surgical history to supplement missing data from the patient's records.

In addition, questions relating to compliance with a rehabilitation programme and an RTP assessment, RTP, time taken to return to some form of sport, ipsilateral knee re-injury and need for secondary surgery, subsequent contralateral knee injury and need for surgery and, pre-injury and post-surgery level of sports participation in the form of Tegner Activity Scores, were included.

The Lysholm Knee Scoring Scale was utilised to measure the individual's function and knee symptoms post-surgery. These scores have been outlined in the literature (Appendix C and D, respectively). (17,18)

Examples of factors presented to the participant in the questionnaire, which may have motivated the participant to complete their rehabilitation programme were 1) *My own desire to return to pre-injury level,* 2) *I am a professional athlete and am reliant on this income,* 3) *my family and 4) my surgeon.*

Examples of factors presented to the participant that may have been barriers to completing their rehabilitation programme were 1) *funding constraints,* 2) *time constraints,* 3) *boring sessions and* 4) *no motivation.* A full list of these factors, the RTP assessment compliance factors, re-injury diagnosis options and type of subsequent surgery performed, are shown in Appendix A.

For BMI, patients were grouped according to the World Health Organisation's (WHO) BMI classification criteria.

All the data in this study were de-identified. Data were captured on *REDCap* and transferred to *Microsoft Office Excel. Statistical Package for the Social Sciences (SPSS)* version 28 was used for data cleaning and analysis. Access to the password protected data is limited to the principal investigator and supervisors only.

3.7. Data analysis

Descriptive statistics were used to describe patient's: biodata (age, sex, height, weight, and body-mass index (BMI)), level of compliance with rehabilitation programme (via number of completed months) and RTP assessment, motivating factors for increased compliance, barriers to compliance, return to sport variables and secondary surgery rates. Frequency, mean, standard deviation, median and ranges are reported as appropriate (**Table 3.1**).

For inferential statistics: i) the Pearson chi-square test was employed to compare RTP rates, re-injury and secondary surgery across completion of rehabilitation and RTP assessment groups. ii) Logistic regression analysis was used to determine patients' factors (for example: age, gender, pre-injury level of sports participation (using the *Tegner Activity Score*)) which predict compliance with a rehabilitation programme and return to play assessment (**Table 3.1**).

Table 3.1: Data analysis plan.

Objective	Data test/tool	Outcome measures
To determine the level of compliance with a rehabilitation programme and return to sports assessment in our cohort.	**Descriptive statistics**	1. Frequencies and percentages of level of compliance and return to sports.
To identify the barriers to compliance and motivating factors for increased compliance in these patients.	**Descriptive statistics**	1. Frequencies and percentages of barriers and motivating factors for compliance.
To analyse whether the following patient characteristics affect compliance level: age, gender, or prior sporting level.	**Inferential statistics** Test of associations using logistic regression analysis to identify factors which predict compliance level.	1. Odds ratio. A p – value <0.05 was considered as statistically significant.
To describe and compare the RTP rates, re-injury and secondary surgery rates between patients who completed a rehabilitation programme and return to play assessment versus those who did not.	**Descriptive statistics** **Inferential statistics** Test of associations using the chi-square test for RTP rates, re-injury, secondary surgery rates and completion of rehabilitation programme.	1. Frequencies and percentages of RTP rates, re-injury and secondary surgery in both groups. 2.Chi-square with degree of freedom. A p - value <0.05 was considered as statistically significant.

3.8. Ethics approval

Ethics approval was obtained from the Human Research Ethics Committee (HREC)(Medical) of the University of the Witwatersrand prior to the collection and analysis of data (clearance certificate number: M211067, **Appendix E**). Permission to use patient data was obtained from *Linksfield Orthopaedic Sports and Rehabilitation Centre Johannesburg* and *Centre for Sports Medicine and Orthopaedics in Rosebank, South Africa* (**Appendix F**).

4. Results

4.1. Data collection process

A total of 100 participants completed the survey. Four participants had ACL reconstructions performed on both knees (on separate occasions during the six-year study period) and the participants completed a survey for each side. Of the 127 surveys accessed, three participants declined to participate after reading the Patient Information Sheet (**Appendix B**) and 24 failed to complete the survey in full. The Prisma flow diagram depicted below, outlines how the investigators reached the sample size of 104 participants (**Figure 4.1)**.

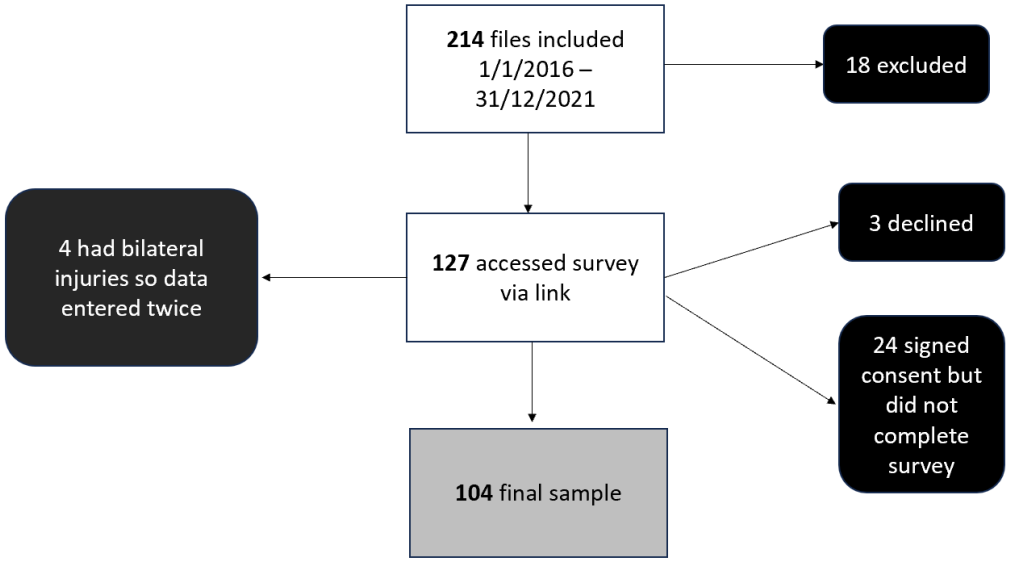


Figure 4.1: Study sample.

4.2. Patient biodata

Of all the participants who underwent ACL reconstruction, 44% (n= 46) were female and 56% (n= 58) were male. Further biodata including age, height, weight, and body mass index (BMI) is presented in Table 4.1, Figure 4.2, and Figure 4.3.

Table 4.1: Participant biodata, level of compliance, return to sport variables and PROM scores.

	N	Min	Max	Mean	Standard deviation (SD)	Median	Interquartile range (IQR)
Age (years)	104	19.00	71.00	36.32	12.83	-	-
Height (cm)	104	145.00	203.00	173.73	9.45	-	-
Weight (kg)	104	51.00	133.00	79.30	14.84	-	-
BMI (kg/m^2)	104	18.78	44.37	26.22	4.27	-	-
Number of months of rehabilitation programme completed	103	.50	18.00	7.23	3.27	-	-
No. Biodex attempts	21	2.00	6.00	3.05	1.24	-	-
Months post-op to pass Biodex	31	3.00	19.00	8.68	4.00	-	-
Months taken to RTS	94	1.00	19.00	8.88	4.45	-	-
Post-op Lysholm Score	104	47.00	100.00	91.02	9.66	95	86-100
Tegner pre-injury level	104	1.00	10.00	7.38	2.16	8	6-9
Tegner post-surgery level	104	1.00	10.00	6.48	2.15	6	5-8
Tegner change	104	-5.00	3.00	-.89	1.43	-	-

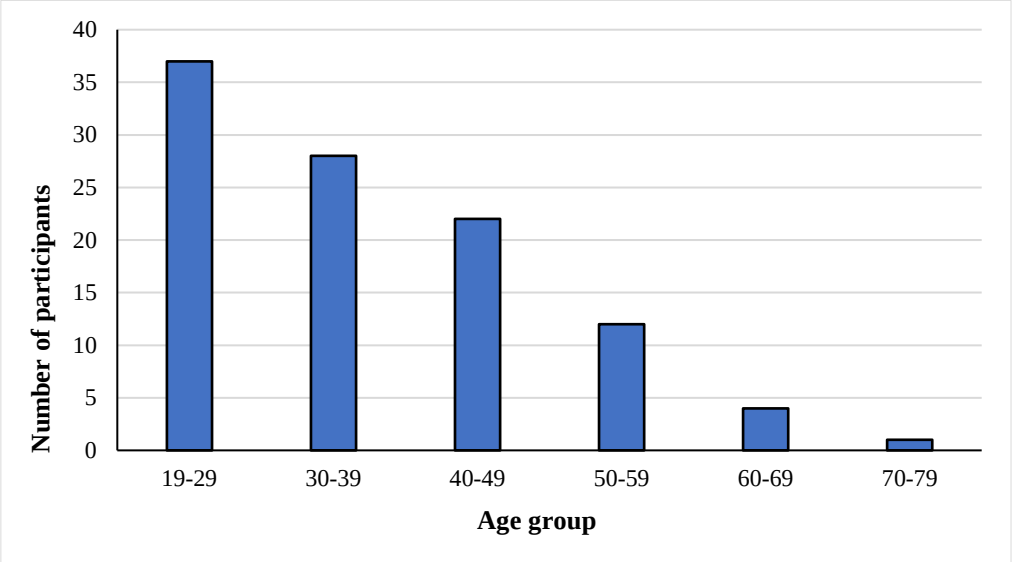


Figure 4.2: Age of participants.

Of all the participants who underwent ACLR, 42.3% (n= 44) were normal weight, 40.4% (n = 42) were overweight, and 17.3% (n= 18) were classified as obese (combining WHO class I, II, III obesity groups) (**Figure 4.3**).

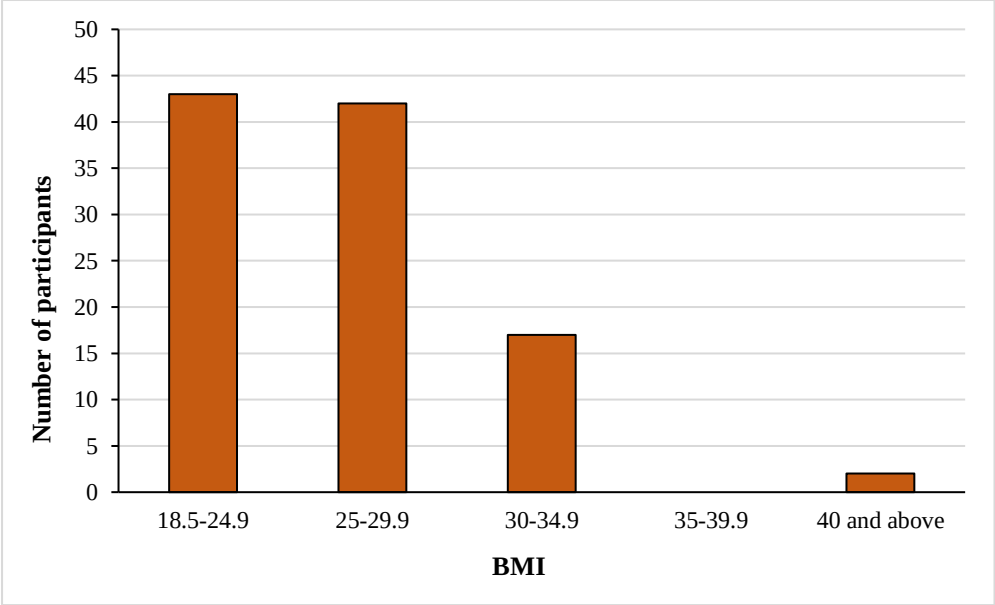


Figure 4.3: BMI of participants.

4.3. Rehabilitation programme

Of the 104 participants, 80% (n = 83) completed their rehabilitation programme in full (**Figure 4.4**). The majority were motivated by their own desire to reach pre-injury level of activity (n = 68) and by their physiotherapist (n = 12) (**Figure 4.5**).

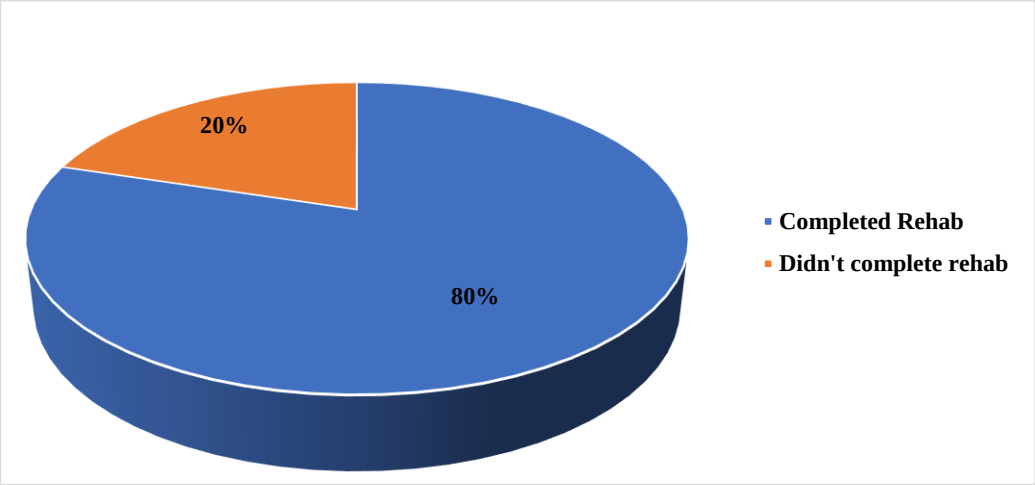


Figure 4.4: Completion of the rehabilitation programme.

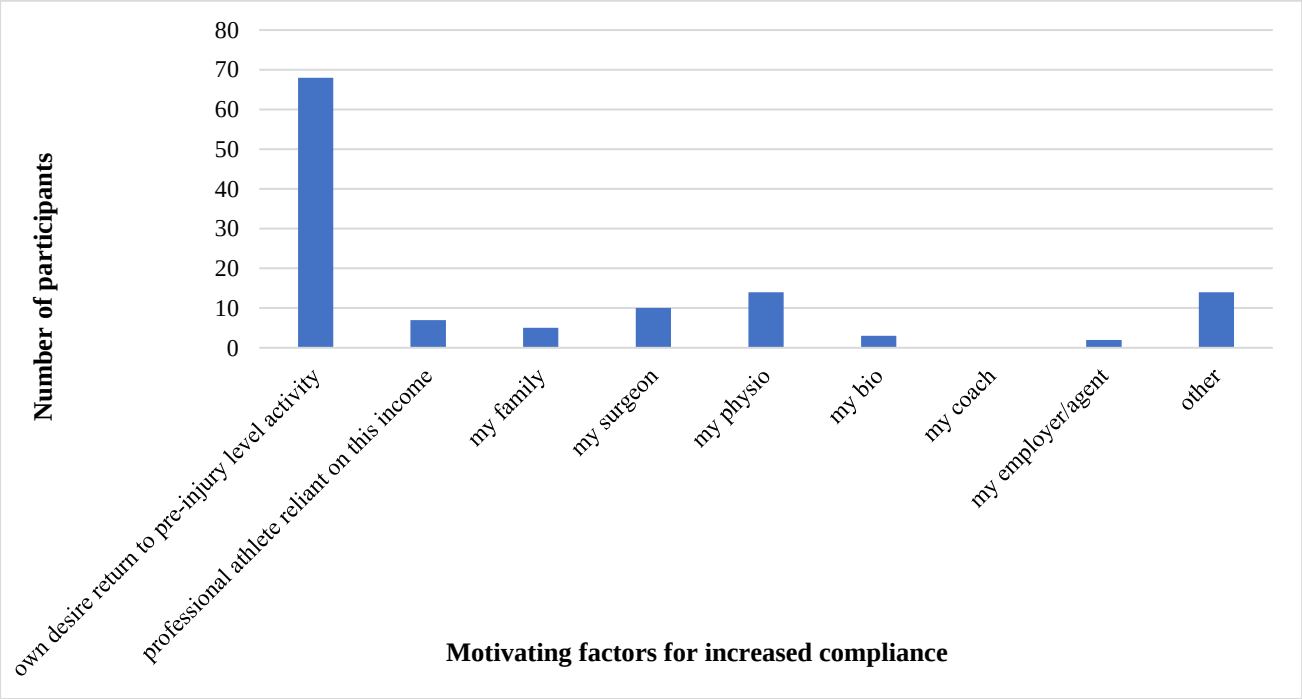


Figure 4.5: Rehabilitation programme: Motivating factors for increased compliance.

The most common barriers to completing the rehabilitation programme were time constraints (n = 8), funding (n = 7), and COVID-19 lockdown restrictions (n = 5) (**Figure 4.6**).

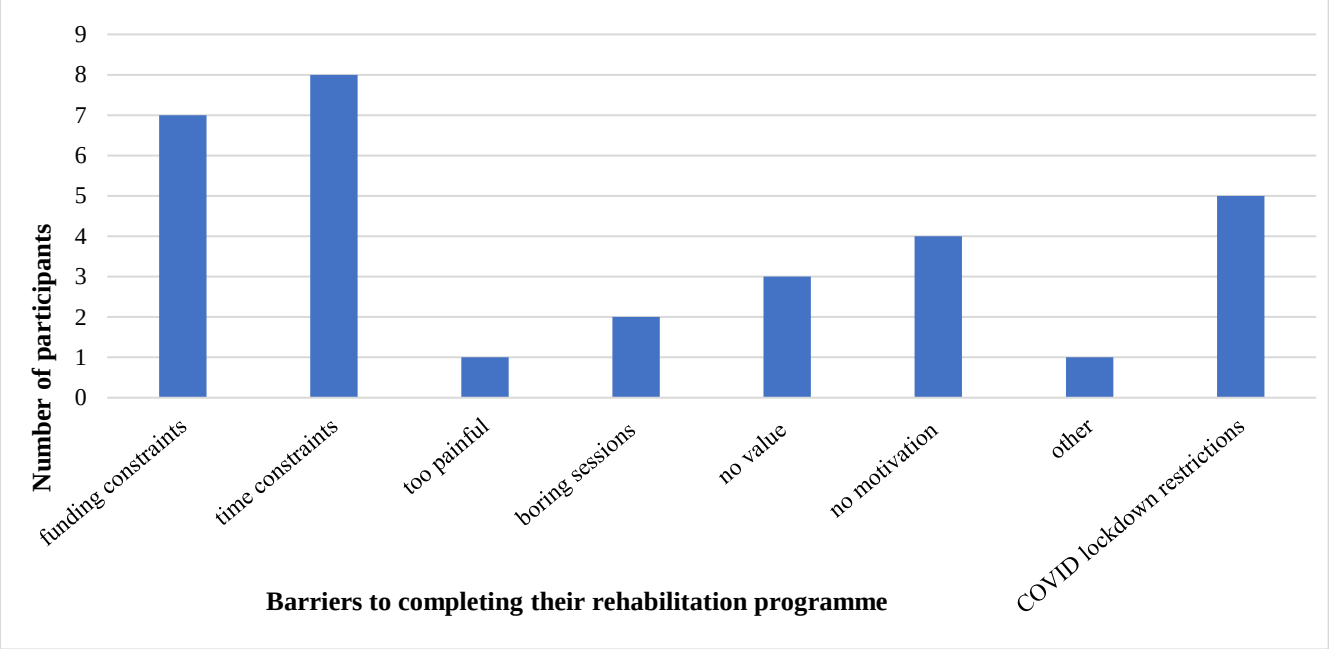


Figure 4.6: Barriers to completing their rehabilitation programme.

Participants stated how long their rehabilitation programme was intended to be and the number of months that they completed, if they did not complete their programme in full. The mean number of rehabilitation programme months completed was 7.23 (**Table 4.1**). Fifty-three percent of the participants completed between 1-6 months of their programme followed by 44%, who completed between 7-12 months. Only 2% of the sample completed more than 12 months of rehabilitation (**Figure 4.7**).

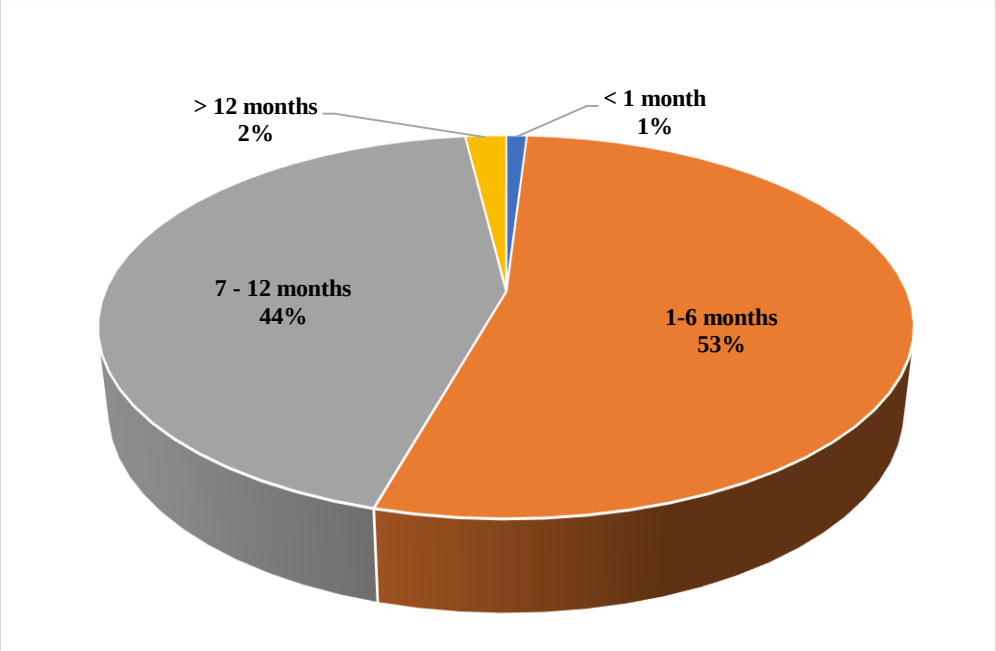


Figure 4.7: Level of compliance: Number of months of their rehabilitation programme completed.

4.4 Return to play assessment

Despite all participants being told by their surgeon to do a RTP assessment before returning to sport, only 54% (n = 56) remember this instruction. Of the total sample, only 48% (n = 50) performed a RTP assessment. Thirty-one individuals did a Biodex assessment as part of their RTP assessment, ten of whom passed it on their first attempt. The remainder (n = 21) took an average of three attempts to achieve the biokineticist's required criteria to constitute a pass. The mean time taken post reconstruction to pass the Biodex assessment was 8.68 months (**Table 4.1**).

Most patients were motivated to complete their RTP assessment because of their biokineticist (n = 21) and wanting to know they were ready (n = 21) (**Figure 4.8**)).

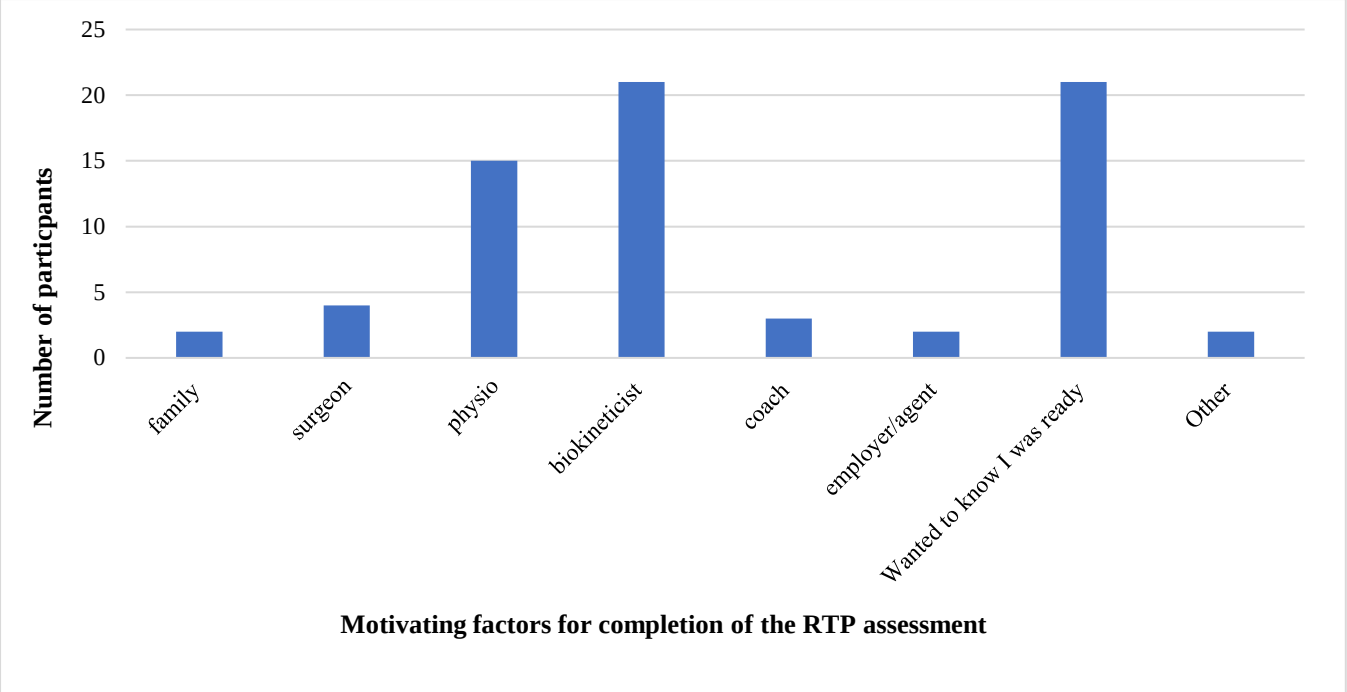


Figure 4.8: Motivating factors for completion of the RTP assessment.

The main reasons why the participants did not complete their RTP assessment were that it was never offered (n = 22) and funding constraints (n = 12).

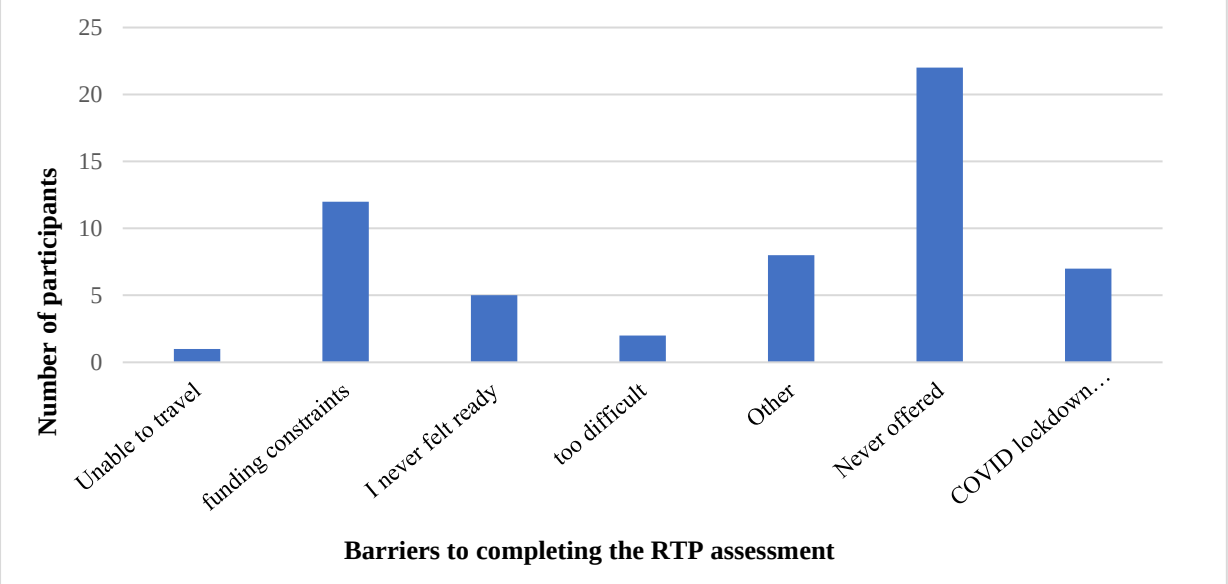


Figure 4.9: Barriers to completing the RTP assessment.

4.5 Return to play variables

The RTP rate was calculated to be 90% in our sample (n = 94). Figure 4.10 outlines how many months participants took to return to some form of sport. Most patients returned to sport between 7-12 months post reconstruction (n = 51), with a mean return time of 8.88 months (**Figure 4.10**). The mean pre-injury Tegner score was 7.38 (out of a maximum of 10). The mean post-surgery Tegner score was 6.48, indicating an overall Tegner change of negative 0.89. Forty-six percent of participants (n = 48) showed a decline in their Tegner score, 51% showed no change (n = 53), and only 3% of the participants showed an improvement. The overall Lysholm score for the cohort on follow up post-surgery was 91.02 (**Table 4.1**).

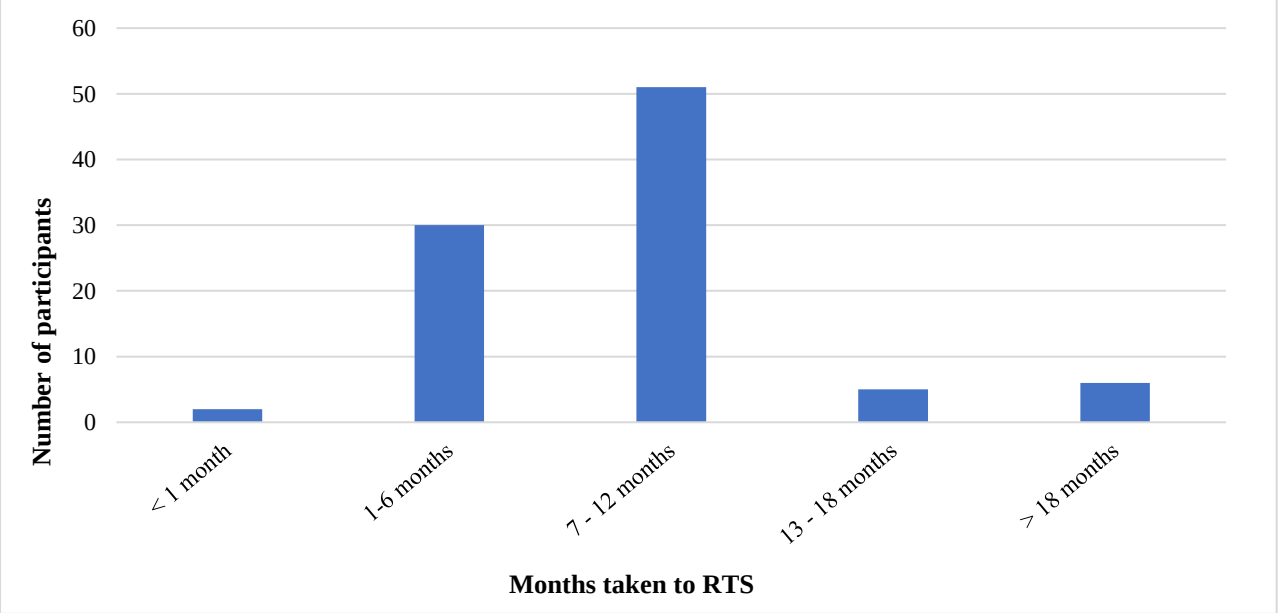


Figure 4.10: Months taken to return to some form of sport.

4.6 Re-injury and further surgery

Nineteen percent of participants had a subsequent knee injury to the same side as the index ACL reconstruction (n = 20). One patient had two further knee injuries to the same side during the follow up period.

Most re-injuries were a re-rupture/torn ACL graft (n = 10) or a meniscus tear (n = 8). Sixteen of the 20 participants required further surgery to the same knee, half of which (n = 8) were a revision ACL reconstruction followed by a meniscus debridement (n = 5).

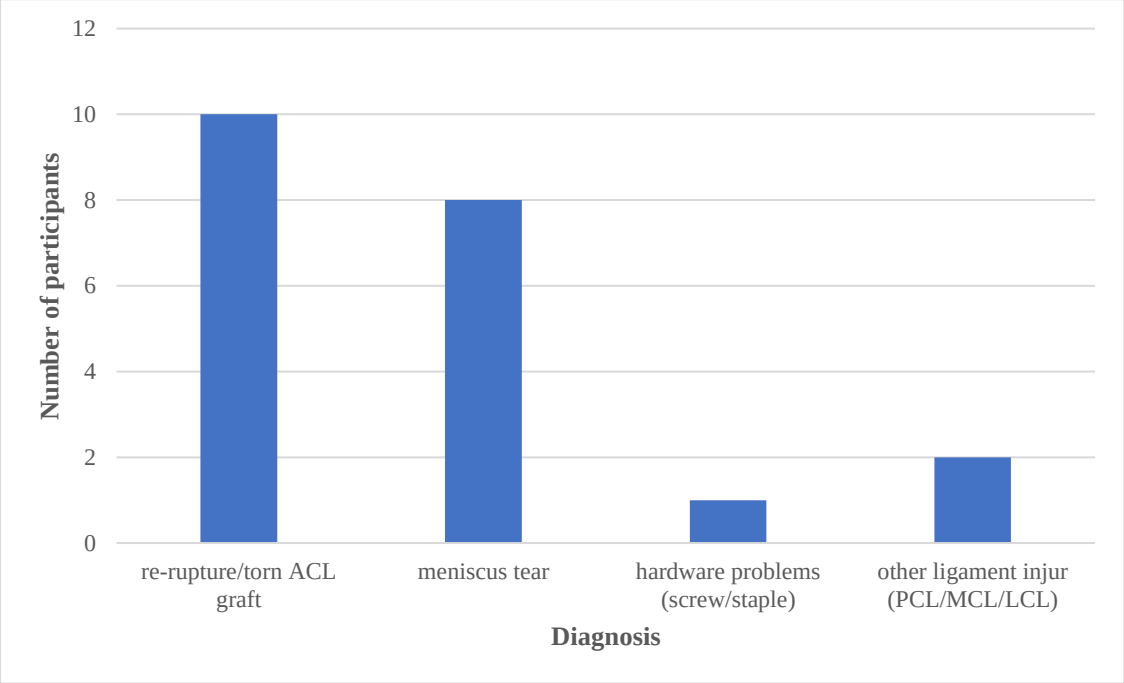


Figure 4.11: Further injury to the same knee.

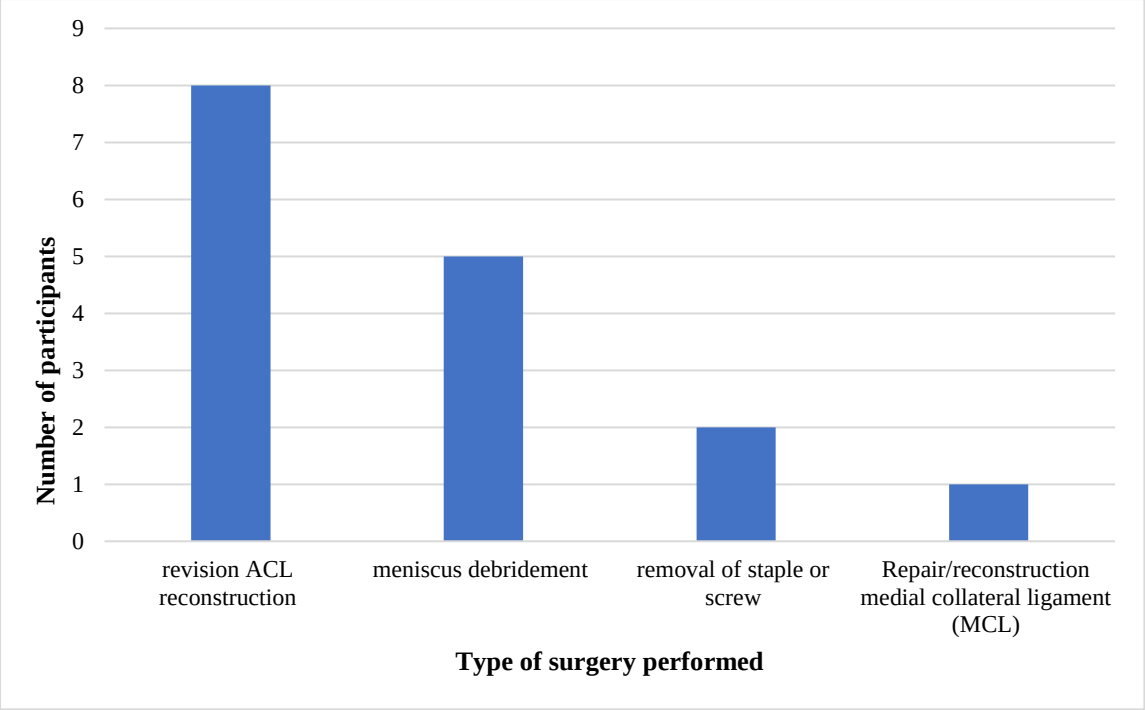


Figure 4.12: Further surgery to the same knee.

Ten percent of participants (n = 11) had a subsequent injury to the other knee. Nine of these injuries were ACL tears. One patient had two further injuries to the other side. Nine of the 11 had further surgery to the other knee, 7 of which were an ACL reconstruction.

4.7 Factors which predict rehabilitation programme compliance level

A linear regression was used to analyse several variables to determine predictors of number of rehabilitation programme months completed. The final model revealed that age, gender, and pre-injuring level were *almost* significant predictors of number of rehabilitation programme months completed (**Table 4.2**).

The overall model was significant (p = .001) and explained 12% of the variance in scores. Patients who were younger, female and had a higher pre-injury Tegner score were more likely to complete more months of the rehab programme.

Table 4.2: Linear regression model to determine predictors of number of rehabilitation programme months completed.

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Standard Error (S.E.)	Beta	t	Significance (Sig)
1	**(Constant)**	5.285	2.874		1.839	.069
	Age (years)	-.062	.028	-.246	-2.191	.031
	Gender	-1.511	.662	-.230	-2.282	.025
	BMI (kg/m^2)	.110	.075	.144	1.469	.145
	Medical condition	-1.224	.746	-.159	-1.640	.104
	Tegner preinjury level	.330	.181	.218	1.827	.071
2	**(Constant)**	8.184	2.102		3.893	<.001
	Age (years)	-.059	.029	-.234	-2.075	.041
	Gender	-1.289	.648	-.197	-1.989	.050
	Medical condition	-.987	.733	-.128	-1.347	.181
	Tegner preinjury level	.291	.180	.192	1.618	.109
3	**(Constant)**	7.529	2.054		3.666	<.001
	Age (years)	-.056	.029	-.222	-1.970	.052
	Gender	-1.150	.643	-.175	-1.789	.077
	Tegner preinjury level	.323	.179	.213	1.806	.074

A logistic regression was run to determine predictors of completing a rehabilitation programme (i.e. individuals were categorised as 'did complete the programme' or 'did not'). It revealed that no variables were significant predictors of whether participants completed their rehabilitation programme in full or not. However, an independent sample T-test was run, and it showed that patients who completed the rehabilitation programme had a significantly higher pre-op Tegner score (p = .009) (**Table 4.3**).

Table 4.3: Pre-op Tegner for completion of rehabilitation programme groups.

	Pre-op	**Statistics**			
	Mean (SD)	*t*	*p*	*d*	*Power*
Completed rehab		2.66	**.009***	0.65	0.84
Yes	7.51 (2.12)[83]				
No	6.86 (2.29)[21]				

4.8 Factors which predict RTP assessment compliance level

A logistic regression was run to determine predictors of completing a return to play assessment. It revealed that only age was a significant predictor of completing a RTP assessment and showed that those who are younger, have a higher chance of completing the RTP assessment (**Table 4.4**).

Table 4.4: Logistic regression model analysing predictors of completing a RTP assessment.

							95% C.I.for EXP(B)	
		B	S.E.	Wald	Sig.	Exp(B)	Lower	Upper
1	**Age (years)**	.05	.02	5.56	.018	1.05	1.01	1.10
	Gender	-.36	.48	.56	.455	.70	.27	1.79
	BMI (kg/m^2)	.01	.06	.06	.812	1.01	.91	1.13
	Medical condition	.21	.54	.15	.695	1.23	.43	3.53
	Tegner pre-injury level	-.17	.13	1.60	.206	.85	.65	1.10
	Constant	-.70	2.06	.11	.736	.50		
2	**Age (years)**	.05	.02	5.75	.016	1.05	1.01	1.10
	Gender	-.33	.46	.50	.478	.72	.29	1.78
	Medical condition	.23	.53	.19	.665	1.26	.45	3.55
	Tegner pre-injury level	-.17	.13	1.68	.195	.84	.65	1.09
	Constant	-.36	1.51	.06	.812	.70		
3	**Age (years)**	.05	.02	5.65	.017	1.05	1.01	1.10
	Gender	-.36	.46	.62	.430	.70	.28	1.71
	Tegner pre-injury level	-.18	.13	1.83	.176	.84	.65	1.08
	Constant	-.23	1.47	.02	.878	.80		
4	**Age (years)**	.05	.02	5.36	**.021**	1.05	1.01	1.10
	Tegner pre-injury level	-.21	.12	2.81	.094	.81	.64	1.04
	Constant	-.14	1.46	.01	.924	.87		

An independent sample T-test was also run for this subset. It showed that patients who completed a RTP assessment had a significantly higher pre-op Tegner score ($p < .001$) and post-op Tegner score ($p < .001$) (**Table 4.5**).

Table 4.5: Pre-op & post-op Tegner for completion of RTP assessment groups.

	Pre-op Tegner	**Statistics**			
	Mean (SD)	*t*	*p*	*d*	*Power*
Completed RTP		3.68	**<.001***	0.72	0.98
Yes	8.14 (1.60)[50]				
No	6.67 (2.37)[54]				
Completed RTP	**Post-op Tegner**				
		4.22	**<.001***	0.83	0.99
Yes	7.34 (1.78)[50]				
No	5.69 (2.18)[54]				

4.9 Comparing completion of rehabilitation groups and completion of RTP assessment groups.

A Pearson chi-square test revealed that RTP rates, re-injury and secondary surgery were not associated with the completion of a rehabilitation programme (**Table 4.6**).

Table 4.6: Comparing completion of rehabilitation programme groups.

	Completed rehab programme		**Statistics**			
	Yes	No	X^2	p	Cramer's V	Power
RTP rate			-	.113	0.16	0.37
Yes	77 (81.9%)	17 (18.1%)				
No	6 (60%)	4 (40%)				
Injury same knee			-	.352	0.12	0.23
Yes	18 (90%)	2 (10%)				
No	65 (77.4%)	19 (22.6%)				
Surgery same knee			-	1.00	0.17	0.41
Yes	14 (87.5%)	2 (12.5%)				
No	4 (100%)	0				
Injury other knee			-	1.00	0.02	0.05
Yes	9 (81.8%)	2 (18.2%)				
No	74 (79.6%)	19 (20.4%)				
Surgery other knee			-	1.00	0.22	0.61
Yes	7 (77.8%)	2 (22.2%)				
No	2 (100%)	0				

A Pearson chi-square test revealed that RTP rates and injury to the other knee were associated with the completion of a RTP assessment (p = .017 and < .001, respectively) (**Table 4.7**).

Table 4.7: Comparing completion of RTP assessment groups.

	Completed RTP Assessment		**Statistics**			
	Yes	No	X^2	p	Cramer's V	Power
RTP rate			-	**.017***	0.25	0.72
Yes	49 (52.1%)	45 (47.9%)				
No	1 (10%)	9 (90%)				
Injury same knee			2.84	.092	0.17	0.41
Yes	13 (65%)	7 (35%)				
No	37 (44%)	47 (56%)				
Surgery same knee			-	1.00	0.11	0.20
Yes	10 (62.5%)	6 (37.5%)				
No	3 (75%)	1 (25%)				
Injury other knee			13.29	**<.001***	0.36	0.96
Yes	11 (100%)	0				
No	39 (41.9%)	54 (58.1%)				
Surgery other knee			-	-	-	
Yes	9 (100%)	0				
No	2 (100%)	0				

5. Discussion

The present study is the first to document the compliance with rehabilitation programmes and the completion of return to sports assessments prior to RTP and what effect this may have on ACLR outcomes in the South African context. We have endeavoured to identify barriers to compliance and motivating factors for increased compliance in our patients who have undergone ACLR surgery. In addition, the study reviewed multiple return to play variables including, amongst others, the re-injury rate and need for further surgery. Lastly, we identified factors which predict increased compliance.

5.1. Patient biodata

ACL injuries are prevalent in young individuals. (2,3) Our sample mean age was 36.32 years (**Figure 4.2)**, which is in keeping with epidemiological norms for ACL injuries reported world-wide.

Women are known to have a higher rate of injury per exposure compared to males, and it has been shown that women are up to eight times more likely to sustain an ACL injury than their male counterparts participating in the same pivoting sports. (2,19) Fifty-six percent of the patients who underwent ACLR in our sample were male (**Table 4.1**). The observed male predominance is likely due to the total number of male sports participants being higher in our setting. Globally, female participation in contact and non-contact pivoting sports is increasing and it is likely that, in future, we will see a female predominance in ACL research cohorts. (2)

An elevated BMI (> 25 kg/m^2) has been associated with a higher re-injury rate, a higher risk of non-contact ACL injuries, and non-isolated ACL injuries (e.g. meniscus or additional ligaments). (20–22). The mean BMI was found to be 26.22 kg/m^2 (**Figure 4.**3) which is in keeping with findings reported by Evans et al. (2012) and Alsayed et al. (2020). (20,21)

For the non-professional, a raised BMI would most likely represent obesity, in contrast to professional athletes, who typically have a higher lean body mass causing a falsely elevated result. (20) Furthermore, our mean pre-injury Tegner score was 7.38 (with a median of 8), noting that a score of greater than 7 indicates that the individual participated in competitive

sports (**Table 4.1**). This may explain our findings, as a large proportion of the individuals referred to our study site were competitive athletes participating in *Rugby Union*, a sport wherein it is favorable to have an increased muscle mass.

We found that almost 58% of our sample were classified as overweight or obese (**Figure 4.3**). This is significantly less than the 70% figure (combined overweight and obese) reported in a Saudi Arabian study. (22) This may be due to differences in overall obesity prevalence rates between countries, the type of sports played in that region, or the number of non-sport related ACL injuries included in each study sample.

5.2 Rehabilitation programme

It is known that incomplete rehabilitation is associated with suboptimal outcomes of ACL reconstruction surgery. (23,24) Edwards et al. (2018) showed that around 33% of patients completed their rehabilitation, defined in their study as at *"least 6 months of supervised rehabilitation integrating a structured return to activity programme"*. They also found that those who completed more than 6 months of supervised rehabilitation were almost 8 times more likely to return to sport compared to those who did not. (25)

Eighty percent of our participants completed their rehabilitation programme in full (**Figure 4.4**). This result is pleasing but comparisons to published literature should be made with caution. Our study survey asked participants what their intended duration of their rehabilitation programme was, and whether in their opinion it was completed in full using a binary 'yes' or 'no' answer. In addition, we did not verify with their treating specialist whether this was truly the intended rehabilitation length, nor did we define what a completed programme is.

Although the mean number of rehabilitation programme months completed was 7.23, of concern is that 54% of the sample completed less than 6 months of rehabilitation, whether that was the intended length or not (**Figure 4.4**).

Patients should be motivated to persist with their rehabilitation programme and, we need to ensure that the rehabilitation specialists we refer to are aware of the current standards and that they promote the completion of longer programmes. (15)

Most of our participants were motivated by 'their own desire to reach pre-injury level of activity' (**Figure 4.5**). This is consistent with research by Walker et al. (2020). (15) Their scoping review found that self-motivation is a psychological factor commonly investigated in the literature and is perceived by patients to be a facilitator of adherence to rehabilitation. (15)

Qualitative studies have shown that patients perceive the physiotherapist to be the primary facilitator of their rehabilitation and are described as their guide and motivator. (26) We found that the 'physiotherapist' was a strong motivator for our patients (**Figure 4.5**). This aligns with findings from a subsequent cross-sectional survey by Walker et al. (2021) which concluded that: *"a good relationship with your rehabilitation provider', 'regular assessment of progress', 'goal setting' ... were the leading facilitators of rehabilitation."*. We echo these sentiments and confirm the key role physiotherapists play in guiding our patients.

'Support and encouragement from those around you' was also identified by Walker et al. as a facilitator of rehabilitation. (27) An interesting difference is that our patients did not perceive their 'bio', 'family', 'coach', 'employer or agent' to be strong motivators in comparison to the aforementioned (**Figure 4.5**). It is important to note that participants were able to select more than one of the options provided when completing the survey.

Fewer barriers to rehabilitation are associated with a faster return to sport and a greater likelihood of returning to pre-injury level. (27) 'Time constraints' was the barrier most frequently cited in this study (**Figure 4.6**). This is somewhat comparable to the concept of *'length and commitment of rehabilitation'* found to a leading barrier by Walker et al. (2021). It is important that the rehabilitation specialist sets clear expectations and warns the patient of the long rehabilitation journey early in the relationship. Sessions should be well planned, efficient, and goal-directed so that patients feel their time is being used constructively.

'Lack of funding' was also perceived as a major barrier (**Figure 4.6**) and this finding aligns with prior literature. (27) Most participants in this study were reliant on private health insurance schemes which, depending on the plan, may be capped for certain services. In addition, many schemes allow clients to utilise a medical savings account for sundry expenses such as physiotherapy appointments and over-the-counter medications. It is imperative that rehabilitation specialists consider these financial limitations and ensure that each session is affordable and of high quality.

‘COVID-19 lockdown restrictions’ were identified as a significant barrier (**Figure 4.6**). This cohort included patients who underwent ACLR in 2020 and 2021. A nationwide lockdown was enforced from 27 March 2020 through to 4 April 2022 when *The National State of Disaster* in South Africa was terminated. Depending on the individual’s living circumstances, home based exercises may have been practically difficult. In addition, the initial stricter lockdown regulations did not allow individuals to walk or run outside and most fitness centres and gyms were closed.

Furthermore, patients may have perceived the risk of contracting the virus at a rehabilitation centre to outweigh the benefit of the sessions. Although most research has shown that a minimally supervised home-based programme is at least as effective as a fully supervised programme, these home-based programmes would have still required introductory sessions and follow up visits during the pandemic. (6,15)

Interestingly ‘low motivation’ was only the fourth most common reason cited as a barrier (**Figure 4.6**). Similar findings were reported by Walker et al. (2021) in their follow up study and concur that this may be due to selection bias, as individuals who are willing to complete a survey may be more inclined to be willing to complete their rehabilitation. (27)

Only one patient stated the session was ‘too painful’ and only two patients stated that the sessions ‘were boring’ (**Figure 4.6**), which suggests that this cohort of patients were referred to specialists who provide enjoyable sessions at an appropriate intensity level. It is imperative that rehabilitation providers identify new or ongoing problems such as knee pain and refer to the treating surgeon, especially when the progress of the rehabilitation has slowed.

5.3 Return to play assessment

To our knowledge to date, no research focussing specifically on RTP assessment compliance has been done. This is most likely due to authors including the RTP assessment as part of the rehabilitation programme in prior research. Similarly, the facilitators of, and barriers to, RTP assessment completion have not been investigated separately.

As a standard, all post operative patients were told by their surgeon to do a RTP assessment prior to RTP. It is concerning that almost half of the cohort did not remember this instruction. In addition, 83 patients stated that they completed their rehabilitation programme but only 60% of patients (n = 50) completed a RTP assessment. Ninety-four patients ultimately returned to some form of sport and therefore a large proportion did so without completing their programme or assessment (**Table 4.1**).

The RTP assessment is one of the final steps in the rehabilitation programme. Research has shown that after six months post-operation, patient-physio contact decreases dramatically as the patient's function improves. (15) The concern is that many individuals are being lost to follow up in the earlier stages of the programme due to the barriers identified in **Chapter 5.2**, the RTP assessment is not offered or discussed prior to this occurrence and thus, the RTP process is undertaken solely by the patient.

Twenty-two individuals stated that they were *'never offered'* the assessment by their provider (**Figure 4.9**). This may simply mean that patients were unaware that they were in fact doing a RTP assessment, but the provider did communicate or labelled this step clearly. However, it may also imply that the rehabilitation providers are truly not offering the assessment to their patients for a variety of reasons, for example: Are time-based protocols still being used? If so, further research is required to investigate why.

The variables involved in RTP decision-making are multifactorial and re-injury is far higher in individuals who return to sport prior to completing some form of a clearance test. We need to ensure that that the rehabilitation specialists we refer to do not rely on time-based protocols alone. (9) A time-based protocol combined with an objective assessment should form the basis of one's clearance criteria, such as those set out by Kyritsis et al. (2016). (14)

Unsurprisingly, 'Funding restraints' and 'COVID-19 lockdown restrictions' were identified as leading barriers to the RTP assessment (**Figure 4.9**) with the rationale being similar to the those outlined in **Chapter 5.2**.

Walker's cohort identified *'fear of re-injury'* as the leading barrier to rehabilitation and a lower fear of re-injury was identified by Ardern et al. as a main determinant of successful RTP. This

is commonly referred to in the literature as 'kinesiophobia' and is most often seen when cutting manoeuvres that mimic the injury mechanism, are re-introduced. (11,27,28)

We did not include this as an option in the rehabilitation section of our survey. However, we included the option *'wanted to know I was ready'* in the RTP assessment section and found that this strongly motivated individuals to complete a RTP assessment (**Figure 4.8**). In addition, many of the individuals described *'safest way forward'* in the comments section available on the survey. This may infer that the successful completion of the RTP assessment is regarded as a marker of physical and psychological readiness and therefore helps to reduce the anxiety around re-injury.

We found that the 'biokineticist' was a strong motivator for our patients to complete the assessment (**Figure 4.8**). Strength testing and sport specific activities are generally guided by the biokineticist in our setting and the influence will therefore be like that of the physiotherapist's in the early rehabilitation stages.

The RTP assessment is integral to the RTP continuum and this needs to be re-enforced with patients at the surgeons follow up visits and at rehabilitation visits. It should be a clear goal for patients to work towards and patients should be reminded of its importance.

Biodex assessment:

We found the overall use of *Biodex* to be very low in our cohort. Only 31 of the 94 individuals who returned to some form of sport, passed a *Biodex* test as part of their RTP assessment (**Table 4.1**). Although the use of a *Biodex* is not yet validated in ACLR rehabilitation, nor is there a standard isokinetic protocol, it is widely considered to be an integral part of RTP decision making. The objective assessment is also used for baseline testing and periodic evaluation. (14)

It is noted that this sophisticated equipment may be too expensive for some providers and patients may not be able to afford the additional service, however where feasible, biokineticists should be encouraged to use the technology.

Most individuals took an average of three attempts to pass the *Biodex* test and did so around the 9-month mark. This is congruent with the overall mean number of months individuals took to return to some form of sport (8.88 months) (**Table 4.1**).

One individual claimed to have passed the *Biodex* after 3-months, but his/her eventual RTP was recorded as 6 months. After reviewing the data, we suspect that it was either an incorrect entry by the participant or baseline testing had been performed and this was misunderstood as a pass.

5.4 Return to play variables

As we have outlined in **Chapter 1.4**, RTP rates are not consistently defined and therefore comparisons to prior research should be made with caution. For the purposes of this study, 'return to play' was defined as a participant retuning to 'some form of sport' whether that was to a pre-injury level, a higher-level or lower-level post operatively.

Our RTP rate was calculated to be 90% and when comparing those who returned to 'some form of sport', this is higher than rates reported by Webster et al. (2021) (85%) and by Arden et al. (2014) in their meta-analysis (81%). (10,11) A minimum follow up of 18 months post ACLR was required for this study. Walden's 2016 prospective study showed high initial RTP rates at 1 year (90%) but a subsequent drop in the rate by approximately 5% at the 3-year mark post-surgery. (7) This illustrates that our RTP rate is equivalent to outcomes reported internationally.

Figure 4.10 illustrates that most patients returned to sport between 7-12 months post reconstruction. In addition, the mean time to RTP (return to some form of sport) was 8.88 months which is in keeping with prior research by Lai et al. (2018) on elite athletes. Their meta-analysis reviewed 15 studies and most reported a RTP within 12 months. Furthermore, six studies reported a mean RTP (defined as return to preinjury level of sport) times between 9-12 months and another six studies reported RTP times between 6-9 months. (29)

Walden et al. (2016) published median layoff times of only 7.4 months to competition and 6.6 months to training. This study was done on professional football players and no mean times were documented. It should be noted that elite athletes appear to return to sport earlier than nonelite athletes. (29) Furthermore, there is insufficient data to confirm whether athletes from

different sports take different amounts of time to RTS.(29) Our cohort included elite and non-elite athletes from a variety of sports and therefore accurate comparisons cannot be made.

Thirty-three percent of participants (n = 31) returned prior to 6-months post-surgery (**Figure 4.10**). It is difficult to draw robust conclusions from this result as we do not know at what level each individual's RTS was and what percentage of these patients are elite athletes (who would RTS sooner). In general, prior to six months post-surgery, it would be appropriate to expect patients to be jogging and performing agility drills. (2) However, a return to pre-injury level prior to six months may place the individual at undue risk. It is known that 'time to RTP' is an important predictor of re-injury and it was found that with every month delay in RTP, there was a 51% reduction in re-injury risk until reaching nine months post-surgery. (2) A minimum 9-month time criterion has been recommended and should be incorporated into any RTP decision making process. (9)

One individual reported RTS prior to one month. We believe that this is an error and that the participant may have mis-interpreted 'some form of sport' as 'some form of exercise' for e.g. commencement of range of motion exercises.

Regarding the Lysholm score, a meta-analysis by Mourabes et al. (2019) evaluated four studies (157 patients) in which patients were treated with hamstrings (HT) autograft. The mean scores after a minimum follow up of one year were 83, 74, 88, and 93. (30) A further study on patient satisfaction post ACLR with hamstrings autograft reported a mean Lysholm score at 12- and 24-months post-surgery as 87 and 89, respectively (31). The overall post-surgery Lysholm score in this study was 91.02 which is in keeping with published literature and implies that a good functional outcome and favourable level of satisfaction was experienced by most of our patients (**Table 4.1**).

The mean pre-op Tegner score published by Leiter et al. (2012) for 64 patients was 7. (32). The post-operative mean Tegner was 6.1 at 12 months and 7 at 24 months in a publication by Zaid et al. (HT autograft). (33) The median Tegner score was 5 and 6 at 12- and 24-months post-surgery, respectively in Minzlaff's study of 60 patients.(31) The present study's mean pre-injury Tegner score was 7.38 (median of 8) and the mean post-surgery Tegner score was 6.48 (median of 6) (**Table 4.1**). This is therefore comparable to international publications.

There is limited data available regarding pre-injury Tegner scores as most authors use the pre-operative score as their baseline. Consequently, we could not find any appropriate data to help understand what our overall Tegner change of negative 0.89 infers.

5.5 Re-injury and further surgery

The same-side-knee re-injury rate was 19.2%. The incidence of ipsilateral graft rupture was 9.6% (n = 10) and the incidence of contralateral ACL injuries was 8.7% (n = 9) which is in keeping with findings reported by Villa et al. (2021) (9.3% and 8.5% respectively). Therefore, our combined second ACL injury incidence was also comparable (18.3%). One should keep in mind that their study included all types of autografts and collateral ligament injuries were not excluded. (1) All individuals in this cohort were reconstructed with autograft which is protective against graft re-rupture when compared to allografts. (1)

The data for the 10 patients who sustained graft ruptures were analysed further and it was found that all these individuals had a Tegner score of 7 or more indicating that they participate in competitive sport. We did not collect data on the type of sports participation, but it is reasonable to assume that many of these competitive athletes returned to high demand pivoting sports, as alluded to in **Chapter 5.1**. Furthermore, the average age of this subset of re-injuries is 23.4 years and the average time to RTP (some form of sport) was 9 months. We know that young athletes retuning to sport within 1 year of surgery are 15 times more likely to suffer a second ACL tear compared to a healthy athlete. (8) Finally, it should be noted that the cause for re-rupture was not investigated. We know that traumatic injuries are more common than technical error as a cause for revision surgery however, these concepts fell outside the scope of this project and may be explored in a follow up study. (2)

Those who return to high demand pivoting sports are also at risk of contralateral ACL tears. The average Tegner score in the contralateral ACL tear subset was 8.5. (2) In addition, Villa et al. found that if the index ACL tear was a non-contact injury or an isolated ACL injury, individuals are at higher risk of contralateral ACL tears. Unfortunately, we did not record the mechanism of injury in this subset, but our inclusion criteria (single ligament injury only) may explain these findings and led to an element of selection bias. (1)

As clinicians we need to identify these risk factors and for these athletes, we should incorporate a longer time to RTP in our clearance criteria to allow for proper graft incorporation and healing to reduce the overall risk. (1)

Eight individuals sustained a meniscus tear, of which 5 required a subsequent meniscus debridement. It is known that concomitant meniscus injury increases the risk of re-injury in ACLR patients. (34) We did not record whether participants had concomitant injures such as chondral lesions or meniscus injuries at index ACL injury or whether they were medial meniscus or lateral meniscus tears and, whether these injuries were debrided, repaired, or left alone at the time of their index ACLR.

Further scrutiny of this subset reveals a high average Tegner score of 8.1 but an average age of 35 years. Re-injuries after ACLR generally occur in younger patients and this result is therefore surprising. However, there is limited evidence on risk factors (e.g. age, level of activity) specifically for meniscus injury post ACLR. It is therefore difficult to comment on these findings.

5.6 Factors which predict rehabilitation programme compliance level

Walker et al. (2021) found that younger individuals appear to attend rehabilitation more frequently and for longer. (15) The present study's overall linear regression model was significant and patients who were younger, female and had a higher pre-injury Tegner score were more likely to complete more months of the rehabilitation programme (**Table 4.2**). Our results are in keeping with findings regarding age as a predictor but, to our knowledge, gender and level of sports participation have not been investigated in the literature. Furthermore, all three of these variables have not been investigated as predictors of RTP assessment completion.

'Time constraints' was listed as a significant barrier in **Chapter 5.2**. It can be postulated that younger patients have more time on their hands, for example: fewer work and family obligations and therefore are able to attend more rehabilitation sessions and for longer. A qualitative study found that older individuals thought that surgeons and physiotherapists did not take their return to sport goals seriously and this was de-motivating. (15)

Individuals who completed the rehabilitation programme had a significantly higher pre-op Tegner score. We postulate that competitive athletes may have a higher level of self-motivation (**Chapter 5.2**). Professional athletes will be surrounded and supported by their team, their coach, and their rehabilitation specialists. In addition, they have the necessary time and resources at their disposal and may be motivated by the mere fact that their sports participation is their source of income.

5.7 Factors which predict RTP assessment compliance level

In terms of predictors of completing a RTP assessment, the logistic regression revealed that those who are younger, have a higher chance of completing the RTP assessment (**Table 4.4**). Gender and level of sports participation were not significant predictors however, an independent sample T-test showed that patients who completed a RTP assessment were competitive athletes (**Table 4.5**). The rationale described in **Chapter 5.6** most likely explains these findings as well.

5.8 Comparing completion of rehabilitation groups and completion of RTP assessment groups

A Pearson chi-square test revealed that RTP rates, re-injury and secondary surgery were not associated with the completion of a rehabilitation programme. This is not in keeping with published literature as it has been shown that: 1) those who complete their rehabilitation are far more likely to RTP and, 2) athletes were found to have a significantly higher chance of graft rupture if a rehabilitation protocol was not followed. (14,25) With reference to **Table 4.6**, we concede that the testing was underpowered (<0.8) with respect to some of the variables. The sample size used was based on the primary endpoint of RTP at one year. To make more accurate statements a larger study focused on these variables should be conducted.

A higher RTP rate was associated with completing a RTP assessment (**Table 4.7**). This confirms the importance of the RTP assessment in the rehabilitation continuum and is in keeping with the principles outlined in **Chapter 5.3**.

One would expect that re-injuries and injuries to the other knee would occur in those who did not complete a RTP assessment. (14) Interestingly, we found that injury to the other knee was associated with the completion of a RTP assessment. We know that the subset of individuals who injured their other knee had high Tegner scores (**Chapter 5.5**) and were competitive athletes who likely returned to high demand pivoting sports which puts them at risk of contralateral ACL tears. As outlined in **Chapter 5.7**, these individuals are more likely to have completed their RTP assessment. Interestingly, injury to the same knee was not associated with completion of a RTP assessment. This variable is also underpowered and perhaps the result would differ with a larger sample size.

6. Limitations

Despite being an informative study, several limitations do exist and need to be addressed:

- A key component of this retrospective study was the utilisation of a prospective online questionnaire to supplement any missing data from clinical records. Depending on the duration of time passed between surgery and completion of the questionnaire, this may affect the accuracy of the data collected from each respective participant.

- Many individuals who met the inclusion criteria had missing or old contact information which limited the number of enrolled patients. In addition, twenty-four individuals signed the consent form but did not go on to complete the survey, which further limited the sample size (Figure 4.1).

- Many of the variables investigated in the questionnaire e.g. 'number of Biodex attempts', 'number of months taken to RTP' or 'successful completion of one's rehabilitation programme' rely on the participant's recall accuracy and honesty. Regarding the latter variable, we asked participants what their intended duration of their rehabilitation programme was, and whether in their opinion it was completed in full using a binary 'yes' or 'no' answer. We did not verify with their treating specialist whether this was truly the intended rehabilitation length, nor did we define and explain to the participant, what a 'completed programme' is.

- RTP rates are not consistently defined in the literature and therefore comparisons to prior research should be made with caution.

- We did not investigate what type of sport individuals participated in and whether their injury was a contact or non-contact twisting injury. This may affect the interpretation of, amongst others: BMI data, re-injury data and RTP data.

- Literature pertaining to motivating factors for increased compliance of rehabilitation programmes and RTP assessments, as well as their respective barriers, is scarce. There are no defined standard set of factors that one can analyse in the descriptive arm of this

study, e.g. ‘lack of funding’ or ‘self-motivation’. Therefore, direct comparisons with prior research in this area should be made with caution.

- Our questionnaire was not standardised and therefore the reproducibility of the study may be compromised.

- There may be an element of selection bias as individuals who are willing to complete a survey may be more inclined to be willing to complete their rehabilitation.

- It should be noted that the COVID-19 restrictions have ceased, and it would be informative to conduct a prospective study in the post pandemic era as this would no longer be a variable to consider. It would also more precisely investigate the reasons for ‘lack of funding’ e.g. which participants have medical aid plans and what plan they are using. In addition, one may hypothesise that a larger portion of individuals medical savings could go towards rehabilitation now that COVID-19 expenses have largely been removed.

- In **Table 4.6** and **Table 4.7** many of the variables are underpowered. Typically, a value of greater than 0.8 would be deemed as sufficient power. The sample size used was based on the primary endpoint of RTP at one year. To make more accurate statements, a larger study over a longer time-frame focusing on these variables should be conducted.

7. Conclusion

Eighty percent of our participants completed their rehabilitation programme in full but of concern is that more than half the sample population completed less than 6 months of their programme and only sixty percent of patients completed a RTP assessment. Patients should be motivated to persist with their rehabilitation programme and, we need to ensure that the rehabilitation specialists we refer them to are aware of the current standards. The RTP assessment is one of the final steps in the rehabilitation programme and its role in preventing re-injury should not be under-estimated.

Most of our participants were motivated by their own desire to reach pre-injury level of activity and by their physiotherapist. Time constraints and lack of funding were cited as barriers to their rehabilitation. Clinicians should be mindful of and target these areas to improve rehabilitation. The physiotherapist plays a key role in the rehabilitation process and sessions should be well planned, efficient, goal-directed, and affordable.

Our RTP rate was calculated to be 90% and when comparing those who returned to 'some form of sport', the mean time to RTP was 8.88 months, which is of international standards. The overall post-surgery Lysholm score in this study was 91.02 which implies that a good functional outcome and favourable level of satisfaction was experienced by most of our patients. Overall, the re-injury rates were low. We identified that younger individuals, females and those who had a higher pre-injury Tegner score were more likely to complete more months of their rehab programme. Similarly, younger, and competitive athletes have a higher chance of completing their RTP assessment.

Lastly, we found that RTP rates, re-injury and secondary surgery were not associated with completion of one's rehabilitation programme, but larger higher-powered studies are required as this is not congruent with current literature.

References

1. Villa F Della, Hägglund M, Villa S Della, Ekstrand J, Waldén M. High rate of second ACL injury following ACL reconstruction in male professional footballers : an updated longitudinal analysis from 118 players in the UEFA Elite Club Injury Study. BJSM. 2021;0:1–8.

2. Sepúlveda F, Sánchez L, Amy E, Micheo W. Anterior cruciate ligament injury: Return to play, function and long-term considerations. Curr Sports Med Rep. 2017;16(3):172–8.

3. Flagg KY, Karavatas SG, Thompson Jr S, Bennett C. Current criteria for return to play after anterior cruciate ligament reconstruction: an evidence-based literature review. Ann Transl Med. 2019;7(S7):S252–S252.

4. Brukner P, Khan K. Brukner & Khan's Clinical Sports Medicine. 5th ed. Mc Graw Hill Education; 2017.

5. Filardo G, de Caro F, Andriolo L. Do cartilage lesions affect the clinical outcome of anterior cruciate ligament reconstruction? A systematic review. Knee Surg Sports Traumatol Arthosc. 2016;4(4).

6. Grant JA, Mohtadi NGH. Two- to 4-Year Follow-up to a Comparison of Home Versus Physical Therapy-Supervised Rehabilitation Programs After Anterior Cruciate Ligament Reconstruction. The American Journal of Sports Science. 2010;38(7):1389–94.

7. Waldén M, Hägglund M, Magnusson H, Ekstrand J. ACL injuries in men ' s professional football : a 15-year prospective study on time trends and return-to-play rates reveals only 65 % of players still play at the top level 3 years after ACL rupture. BJSM. 2016;50:744–50.

8. Nagelli C V, Hewett TE, Laboratories B, Clinic M, Clinic M, Clinic M, et al. Should return to sport be delayed until two years after anterior cruciate ligament reconstruction? Biological and functional considerations. Sports Med. 2018;47(2):221–32.

9. Burgi CR, Peters S, Ardern CL, Magill JR, Gomez CD, Sylvain J, et al. Which criteria are used to clear patients to return to sport after primary ACL reconstruction ? A scoping review. Br J Sports Med. 2019;53:1154–61.

10. Webster KE, Feller JA. Second ACL Injury Rates in Younger Athletes Who Were Advised to Delay Return to Sport Until 12 Months After ACL Reconstruction. The Orthopaedic Journal of Sports Medicine. 2021;9(2):1–6.

11. Ardern C, Taylor N, Feller J. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. BJSM. 2014;48(21):1543–52.

12. Bodkin SG, Rutherford MH, Diduch DR, Brockmeier SF, Hart JM. How Much Time Is Needed Between Serial '" Return to Play "' Assessments to Achieve Clinically

Important Strength Gains in Patients Recovering From Anterior Cruciate Ligament Reconstruction ? Am J Sports Med. 2020;48(1):70–7.

13. Undheim M, Cosgrave C, King E. Isokinetic muscle strength and readiness to return to sport following anterior cruciate ligament reconstruction: is there an association? A systematic review and a protocol recommendation. Br J Sports Med. 2015;49(20):1305–10.

14. Kyritsis P, Bahr R, Landreau P. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. Br J Sports Med. 2016;50(15):946–51.

15. Walker A, Hing W, Lorimer A. The Influence, Barriers to and Facilitators of Anterior Cruciate Ligament Rehabilitation Adherence and Participation: a Scoping Review. Vol. 6, Sports Medicine - Open. Springer; 2020.

16. Roos E. Outcome after anterior cruciate ligament reconstruction - a comparion of patients' and surgeons' assessments. Scand J Sci Sports. 2001;11(5):287–91.

17. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the lysholm score and tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. American Journal of Sports Medicine. 2009;37(5):890–7.

18. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clinical Orthop Relat Res. 1985;198:43–9.

19. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. American Journal of Sports Medicine. 1995;23:964–701.

20. Evans KN, Kilcoyne KG, Dickens JF, Rue JP, Giuliani J, Gwinn D, et al. Predisposing risk factors for non-contact ACL injuries in military subjects. Knee Surgery, Sports Traumatology, Arthroscopy. 2012 Aug;20(8):1554–9.

21. Alsayed H, Alkhateeb M, Aldossary AA, Houbani K, Aljamaan Y, Aldakheel D, et al. Risk of Anterior Cruciate Ligament Injury in Obese Population: A Retrospective Study in a Single Center in Saudi Arabia. 2020; Available from: https://doi.org/10.21203/rs.3.rs-32771/v1

22. Alsayed HN, Alkhateeb MA, Aldossary AA, Houbani KM, Aljamaan YM, Alrashidi YA. Risk of anterior cruciate ligament injury in population with elevated body mass index. Med Glas. 2023 Feb 1;20(1):83–7.

23. Diermeier TA, Rothrauff BB, Engebretsen L, Lynch A, Svantesson E, Hamrin Senorski EA, et al. Treatment after ACL injury: Panther Symposium ACL Treatment Consensus Group. In: British Journal of Sports Medicine. BMJ Publishing Group; 2021. p. 14–22.

24. Beischer S, Hamrin Senorski E, Thomee C, Samuelsson K, Thomee R. Young athletes return too early to knee-strenuous sport, without acceptable knee function after anterior cruciate ligament reconstruction. Knee Surgery. 2018;26(7):1966–74.

25. Edwards P, Ebert J, Joss B, Ackland T, Annear P, Buelow J, et al. Patient Characteristics and Predictors of Return to Sport at 12 Months After Anterior Cruciate Ligament Reconstruction: The Importance of Patient Age and Postoperative Rehabilitation. Orthop J Sports Med. 2018;9(6).

26. Paterno M V., Schmitt LC, Thomas S, Duke N, Russo R, Quatman-Yates CC. Patient and parent perceptions of rehabilitation factors that influence outcomes after anterior cruciate ligament reconstruction and clearance to return to sport in adolescents and young adults. Journal of Orthopaedic and Sports Physical Therapy. 2019;49(8):576–83.

27. Walker A, Hing W, Lorimer A, Rathbone E. Rehabilitation characteristics and patient barriers to and facilitators of ACL reconstruction rehabilitation: A cross-sectional survey. Physical Therapy in Sport. 2021 Mar 1;48:169–76.

28. Walker A, Hing W, Gough S, Lorimer A. 'Such a massive part of rehab is between the ears'; barriers to and facilitators of anterior cruciate ligament reconstruction rehabilitation: a qualitative focus group analysis. BMC Sports Sci Med Rehabil. 2022 Dec 1;14(1).

29. Lai CCH, Ardern CL, Feller JA, Webster KE. Eighty-three per cent of elite athletes return to preinjury sport after anterior cruciate ligament reconstruction: A systematic review with meta-analysis of return to sport rates, graft rupture rates and performance outcomes. In: British Journal of Sports Medicine. BMJ Publishing Group; 2018. p. 128–38.

30. Mouarbes D, Menetrey J, Marot V, Courtot L, Berard E, Cavaignac E. Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis of Outcomes for Quadriceps Tendon Autograft Versus Bone–Patellar Tendon–Bone and Hamstring-Tendon Autografts. American Journal of Sports Medicine. 2019 Dec 1;47(14):3531–40.

31. Minzlaff P, Heidt T, Feucht MJ, Plath JE, Hinterwimmer S, Imhoff AB, et al. Patient satisfaction with health is substantially improved following ACL reconstruction. Knee Surgery, Sports Traumatology, Arthroscopy. 2018 Feb 1;26(2):582–8.

32. Leiter JRS, Gourlay R, McRae S, de Korompay N, MacDonald PB. Long-term follow-up of ACL reconstruction with hamstring autograft. Knee Surgery, Sports Traumatology, Arthroscopy. 2014;22(5):1061–9.

33. Zaid HHG, Chenwei N, Xu H, Yang G, Li X. Clinical and arthroscopic outcomes of single-bundle anterior cruciate ligament reconstruction using autologous hamstrings augmented with ligament augmentation and reconstruction systems compared with four-strand hamstring tendon grafts alone. Int Orthop. 2023 Jan 1;47(1):151–64.

34. Adhitya IPGS, Yu WY, Kurniawati I, Lin MR. Risk factors of knee reinjury after anterior cruciate ligament reconstruction. Int Orthop. 2024;

Appendices

Appendix A: Research questionnaire

Part 1 ACL Reconstruction Survey

Please complete the survey below.

Thank you!

Thank you for agreeing to be a participant in this study. There are three main sections to the survey.

Part 1: Please answer the questions below.

1)	Age	_____
2)	Date of birth	_____
3)	Gender	◯ Female ◯ Male
4)	Phone number	_____
5)	Which knee did you injure?	◯ Left ◯ Right ((The knee you initially required surgery on))
6)	Height (cm)	_____
7)	Weight (kilograms)	_____
8)	If you suffer from any of the following medical conditions, please tick the appropriate box.	☐ None (N/A) ☐ Acne (that requires the use of Roaccutane (Isotrentinoin) ☐ Asthma ☐ Cancer ☐ Chronic kidney disease ☐ Chronic liver disease ☐ Congestive heart failure ☐ Coronary disease ☐ Dementia ☐ Diabetes mellitus type I ☐ Diabetes mellitus type II ☐ Seizure Disorder ☐ Hepatitis ☐ Hypertension ☐ Immune deficiency/HIV/AIDS ☐ Multiple Sclerosis ☐ Other Chronic respiratory disease or disorders (e.g.COPD, Emphysema) ☐ Psychological and/or psychiatric condition ☐ Substance Use Disease or Disorders ☐ Cardiomyopathy ☐ Congenital Heart Disease ☐ Congenital syndromes/anomalies and genetic conditions ☐ Rheumatologic conditions (e.g. rheumatoid arthritis, systemic lupus erythematosus, vasculitis)
9)	Please list any chronic medical conditions (not listed above) that you suffer from.	_____
10)	If you have selected/listed a medical condition, do you think that it may have interfered with your ACL rehabilitation process?	_____ (If yes, please name the condition and elaborate. If no, please leave blank.)
11)	Did you complete a rehabilitation protocol with a Biokineticist or Physiotherapist?	◯ No ◯ Yes ('Completion of a protocol' is defined as doing at least 9 months of rehabilitation after surgery or until your bio/physio said you completed your rehabilitation with them.)
12)	Who was your Bio/Physio?	

13) How long was your rehabilitation protocol intended to be, when starting (in months)?

- ◯ < 6
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ > 18
- ◯ unsure/don't know

14) If you completed your protocol...

What/Who motivated you to complete the rehabilitation protocol?

- ◯ my own desire to return to pre-injury level of activity
- ◯ I am a professional athlete and am reliant on this income
- ◯ my family
- ◯ my surgeon
- ◯ my physio
- ◯ my biokineticist
- ◯ my coach
- ◯ my employer/agent
- ◯ other
- ◯ N/A

(Single best answer. If you did not complete a protocol then select "N/A")

15) 1) Please elaborate on your choice above.

2) Please elaborate if there was more than one factor that motivated you.

3) If you selected 'Other', please elaborate.

_____

(If you did not complete the rehabilitation: Write "N/A")

16) If you DID NOT complete your intended protocol:

How many months of the rehabilitation protocol did you complete?

- ◯ < 1
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ N/A

((If you completed your prescribed protocol then please mark "N/A"))

17) If you DID NOT complete your protocol:

Please select the possible barrier and/or challenge you faced.

- ◯ funding constraints
- ◯ time constraints
- ◯ too painful
- ◯ boring sessions
- ◯ no value
- ◯ no motivation
- ◯ other
- ◯ N/A

(Single best answer. If you did complete a protocol then select: 'N/A')

18) 1) Please elaborate on your choice above.

2) Please elaborate if there was more than one barrier and/or challenge you faced.

3) If you selected 'Other', please elaborate.

_____

((If you completed your prescribed rehabilitation then please mark "N/A"))

19) Were you specifically told to do a 'return to play' assessment before returning to sport? (By your surgeon/physio/bio)

- ◯ No
- ◯ Yes

20) Did you do a 'return to play' assessment?

- ◯ No
- ◯ Yes

21) If yes:

What/who motivated you to complete the 'return to play' assessment?

- ◯ my family
- ◯ my surgeon
- ◯ my physio
- ◯ my biokineticist
- ◯ my coach
- ◯ my employer/agent
- ◯ I wanted to know I was ready
- ◯ Other
- ◯ N/A

(If you did not complete a RTP assessment: Mark "N/A")

22) 1) Please elaborate on your choice above.

2) Please elaborate if there was more than one factor that motivated you.

3) If you selected 'Other', please elaborate.

_____

(If you did not complete a RTP assessment then write "N/A")

23) If you DID NOT complete your 'return to play' assessment:

Please select the possible barrier and/or challenge you faced.

- ◯ my biokineticist couldn't do it
- ◯ I was unable to travel
- ◯ funding constraints
- ◯ I never felt ready
- ◯ too difficult
- ◯ Other
- ◯ N/A

(Single best answer. If you completed your return to play assessment then please mark "N/A")

24) 1) Please elaborate on your choice above.

2) Please elaborate if there was more than one barrier and/or challenge you faced.

(If you completed your return to play assessment then please write "N/A")

3) If you selected 'Other', please elaborate.

25) Did you do a Biodex assessment?
- ◯ No
- ◯ Yes

26) Did you pass the Biodex test first time?
- ◯ No
- ◯ Yes
- ◯ N/A (did not do a Biodex)

27) If you did not pass the Biodex first time, how many Biodex attempts did you take before returning to sport?
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ more than 5 attempts
- ◯ N/A (did not do a biodex)
- ◯ N/A (passed first time)

28) How many months after surgery did you pass the Biodex assessment?
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ More than 18 months
- ◯ N/A (did not do a Biodex)

29) Can we contact your biokineticist for your results?
- ◯ No
- ◯ Yes

30) Did you complete functional testing?

For example: jumping, running between cones or sport-specific drills
- ◯ No
- ◯ Yes

31) How long after your surgery did you return to some form of sport? (in months)
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ >18 months
- ◯ Never returned to any form of sport

32) Were you seen by your surgeon before returning to play?
- ◯ No
- ◯ Yes

('play' (i.e. sport or activity))

33) Have you re-injured your knee since returning to play?

(NB: referring to the same side of your original ACL reconstruction)
- ◯ No
- ◯ Yes

34) Please select the new injury and/or diagnosis:

(NB: referring to the same side of your original ACL reconstruction)
- ◯ Re-rupture/torn ACL graft
- ◯ Meniscus tear
- ◯ Infection
- ◯ Hardware problems (screws or staple)
- ◯ Other ligament injury (PCL/MCL/LCL)
- ◯ Other
- ◯ N/A

35) Have you had any further surgery on the SAME knee?

If yes: Please select what type of surgery was done.
- ☐ revision ACL reconstruction
- ☐ meniscus debridement
- ☐ meniscus repair
- ☐ lateral EAT (extra-articular tenodesis)
- ☐ removal of staple or screw
- ☐ wound debridement
- ☐ Repair/reconstruction posterior cruciate ligament (PCL)
- ☐ Repair/reconstruction medial collateral ligament (MCL)
- ☐ Repair/reconstruction lateral collateral ligament (LCL)
- ☐ other
- ☐ N/A - no further surgery was required

(If no further surgery was done: Mark "N/A")

36) If you selected 'other': Please describe what was done.

37)	When was the surgery performed?	_____ ((NB: referring to the same side of your original ACL reconstruction))
38)	Have you re-injured your OTHER knee since returning to play?	◯ No ◯ Yes
39)	Please select the injury and/or diagnosis: (NB: referring to the other knee)	◯ ACL tear ◯ Meniscus tear ◯ Cartilage damage ◯ Other ligament injury (PCL/MCL/LCL) ◯ Other ◯ N/A
40)	Have you had any further surgery on the OTHER knee? If yes: Please select what type of surgery was done.	☐ ACL reconstruction ☐ meniscus debridement ☐ meniscus repair ☐ lateral EAT (extra-articular tenodesis) ☐ Repair/reconstruction posterior cruciate ligament (PCL) ☐ Repair/reconstruction medial collateral ligament (MCL) ☐ Repair/reconstruction lateral collateral ligament (LCL) ☐ Other ☐ N/A - no surgery performed (If no surgery was done: Mark "N/A")
41)	If you selected 'other': Please describe what was done.	_____ (If no further surgery was done: Write "N/A")
42)	When was the surgery performed?	_____ ((NB: referring to the other side))

Appendix B: Participant information sheet and consent form

Participant Information And Informed Consent

Please complete the survey below.

Thank you!

COMPLIANCE WITH REHABILITATION AND RETURN TO PLAY ASSESSMENTS IN PATIENTS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCITON

Dear Reader,

My name is Dr Laine Alexander and I am an Orthopaedic Registrar enrolled at the University of the Witwatersrand. I would like to invite you to take part in this research study.

What is the purpose of this Research Study and why have I been chosen?

The research study aims to look at patient's compliance with a rehabilitation program and return to sports assessment in those who underwent ACLR and related surgery at the Linksfield Orthopaedic Sports and Rehabilitation Centre Johannesburg and Centre for Sports Medicine and Orthopaedics in Rosebank, South Africa. We also want to identify the barriers to compliance and motivating factors for increased compliance. We can use this data to improve access to appropriate rehabilitation and testing and thereby potentially increase safe return to play. This may be of benefit to you and, individuals like yourself who sustain to these injuries in future. The findings will also serve as an audit on ACLR and related surgery outcomes and allow us to see how we can improve. All patients who had this particular injury and subsequent surgery are going to be contacted in a similar fashion and will be invited to partake in the study.

What do I have to do for the study?

You will be asked several questions regarding your rehabilitation and return to sport after your ACL surgery via this online survey. The questionnaire will take approximately 10 - 15 minutes to complete and we require your consent prior to commencement.

If further information is required, or the participant requires any assistance in completing the questionnaire, patients may be contacted telephonically. All telephonic communication will be recorded and stored on a secure drive.

Do I have to take part?

Your participation in this study is entirely voluntary. Should you wish to discontinue your participation, you may do so freely at any time and without giving a reason. If you choose not to participate or to withdraw from the study, there will be no effect on the care and treatment that you receive from the hospital/doctor in any way.

Will my taking part in this study be kept confidential?

All information obtained during this study will be kept confidential. All your medical information will remain filed at the practices and only authorised personnel (myself and my supervisors; Dr Gelbart and Dr Milner) will have access to this information. All questionnaire information will be assigned a research number to ensure it is kept anonymous. Data may be reported in scientific journals and will not include any information that identifies you as a participant in this study. Data will be kept for two years if published or six years if not published, after this period the data will be destroyed.

Whom do I call if I have questions or problems?

I would like to offer you time now to ask any questions that you may have. If you would like more information, have any problems, concerns or questions about the study or experience research related issues, please contact Dr Alexander on 0662242394 at any time.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research. If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za.

Thank you for reading this study information sheet.

I, hereby consent to the use of my medical data in the participation of medical research. No identifiable details shall be included. I have been informed of the nature of this study and I do understand that there are no risks or harm involved and that my participation is voluntary, that participation should not compromise the standard of care treatment in any way whatsoever. I may also choose to terminate participation without explanation and consequence at any time whatsoever. I have been assured that my personal details will remain confidential. I do hereby confirm that all my concerns have been adequately and sufficiently addressed to my satisfaction by the investigator.

⊗ Yes, I agree to participate

I, hereby consent to audio recording of any follow up telephonic communication.
I understand that:
- The recording will be stored in a secure location with restricted access to the researcher and supervisors.
- The recording may be transcribed and any information that could identify me will be removed.
- The recordings will be erased within either two years of the publication of the research or six years if no publications arise.
- Anyone wishing to access this information in future will first have to obtain approval from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand.
- Direct quotes from my interview, without any information that could identify me, may be cited in the research report.

⊗ Yes, I agree to participate

Participant's first name:

Laine

Participant's last name:

Alexander

Date: 06-12-2022

Signature (draw with mouse or finger):



Appendix C: Tegner activity score (17,18)

Part 3: Tegner Activity Score

Please complete the survey below.

Thank you!

Part 3: The Tegner Activity Score

Below is a list of activities levels:

Level 10: Competitive sports - soccer, football, rugby (national elite).
Level 9: Competitive sports - soccer, football, rugby (lower divisions).
Level 8: Competitive sports - athletics (jumping), squash, skiing.
Level 7: Competitive sports - athletics (running), tennis, handball.
Level 6: Recreational sports - tennis and badminton, handball basketball, jogging at least 5 times per week.
Level 5: Work - heavy labour (e.g. construction).
Competitive sports - cycling, cross-country skiing.
Recreational sports - jogging on uneven ground at least twice weekly.
Level 4 Work - Moderately heavy labour (e.g. truck driver or heavy domestic work).
Level 3 Work - light labour (e.g. nursing).
Level 2 Work - light labour.
Walking on uneven ground possible, but impossible to hike or walk in a forest.
Level 1 Work - Sedentary (e.g. secretarial).
Walking on even ground possible.
Level 0 Sick leave or disability pension because of knee problems.

Instructions: Please indicate the highest level of activity that you participated in BEFORE your injury and the highest level you are currently able to participate in AFTER your surgery.

1) Pre-injury level:
- ○ 10
- ○ 9
- ○ 8
- ○ 7
- ○ 6
- ○ 5
- ○ 4
- ○ 3
- ○ 2
- ○ 1

2) Level after surgery
- ○ 10
- ○ 9
- ○ 8
- ○ 7
- ○ 6
- ○ 5
- ○ 4
- ○ 3
- ○ 2
- ○ 1

Appendix D: Lysholm Knee Scoring Scale (18)

Part 2: Lysholm Knee Scoring Scale

Please complete the survey below.

Thank you!

Instructions: Below are common complaints which people frequently encounter when they have knee problems. Please tick the statement which best describes your condition.

1)	Limp:	◯ I have a severe and constant limp when I walk (0) ◯ I have a slight or periodical limp when I walk (3) ◯ I have no limp when I walk (5)
2)	Using cane or crutches:	◯ I do not use a cane or crutches (5) ◯ I use a cane or crutches with some weight-bearing (2) ◯ Putting weight on my hurt leg is impossible (0)
3)	Locking sensation in the knee:	◯ I have no locking and no catching sensations in my knee (15) ◯ I have catching sensation but no locking sensation in my knee (10) ◯ My knee locks occasionally (6) ◯ My knee locks frequently (2) ◯ My knee feels locked at this moment (0)
4)	Giving way sensation from the knee:	◯ My knee never gives way (25) ◯ My knee rarely gives way, only during athletics or other vigorous activities (20) ◯ My knee frequently gives way during athletics or other vigorous activities, in turn I am unable to participate in these activities (15) ◯ My knee occasionally gives way during daily activities (10) ◯ My knee often gives way during daily activities (5) ◯ My knee gives way every step I take (0)
5)	Pain:	◯ I have no pain in my knee (25) ◯ I have intermittent or slight pain in my knee during vigorous activities (20) ◯ I have marked pain in my knee during vigorous activities (15) ◯ I have marked pain in my knee during or after walking more than 1 mile (10) ◯ I have marked pain in my knee during or after walking less than 1 mile (5) ◯ I have constant pain in my knee (0)
6)	Swelling:	◯ I have no swelling in my knee (10) ◯ I have swelling in my knee only after vigorous activities (6) ◯ I have swelling in my knee after ordinary activities (2) ◯ I have swelling constantly in my knee (0)
7)	Climbing stairs:	◯ I have no problems climbing stairs (10) ◯ I have slight problems climbing stairs (6) ◯ I can climb stairs only one at a time (2) ◯ Climbing stairs is impossible for me (0)
8)	Squatting:	◯ I have no problems squatting (5) ◯ I have slight problems squatting (4) ◯ I cannot squat beyond a 90 degree bend in my knee (2) ◯ Squatting is impossible because of my knee (0)

Appendix E: WITS Human Research Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Dr Laine Alexander

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M211067

NAME: (Principal Investigator)	Dr Laine Alexander
DEPARTMENT:	Orthopaedic Surgery Netcare Linksfield Hospital
PROJECT TITLE:	Compliance with rehabilitation and return to play assessments in patients after anterior cruciate ligament reconstruction
DATE CONSIDERED:	29/10/2021
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the University Registrar's office <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Dr B. Gelbart and Dr B. Milner
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	12/04/2022

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I **agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **October** and will therefore be due in the month of **October** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

13/4/22
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix F: Netcare Linksfield Hospital Approval

Netcare Linksfield Hospital

Tel: +27 (0) 11 647 3400
Fax: +27 (0) 11 640 3576
24 12th Avenue, Linksfield West, Johannesburg, South Africa
PO Box 46337, Orange Grove, 2119, South Africa
www.netcare.co.za

Date: 23 September 2021

To: University Of THE WITWATERSRAND: Ethics Committee

RESEARCH TO BE CONDUCTED IN NETCARE FACILITY

The Management of Netcare Linksfield Hospital has taken note of the application for ethical approval by the University of the Witwatersrand Ethical Committee for the following research study to be conducted:

"Compliance with rehabilitation and return to play assessments in patients after anterior cruciate ligament reconstruction: a South African perspective"

In principle the Netcare Linksfield Hospital Management does not have any reservations for the above mentioned research to be conducted on its premises subject to unconditional ethics approval being granted.

We furthermore confirm that an application will then be made to the Netcare Research Operations Committee and that the research may not commence prior to receipt of FINAL APPROVAL from the Netcare Research Operations Committee.

Yours faithfully

Signed by Hospital Management
Lisete Vieira
Hospital General Manager

23.09.2021
Date

Appendix G: WITS Research Protocol Committee Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

03 January 2022
Person No: 2527848
PAG

Dr LAJ Alexander
22 Waters Edge Estate
Big Bay
Bloubergrant
7441
South Africa

Dear Dr Laine Alexander

Master of Medicine in Orthopaedic Surgery: Approval of Title

We have pleasure in advising that your proposal entitled *Compliance with rehabilitation and return to play assessments in patients after anterior cruciate ligament reconstruction* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences