

This paper was awarded the ML Roberts Prize in the category of literature review and the Asics Research Award for undergraduate research undertaken by physiotherapy students at the School of Physiotherapy, Auckland University of Technology. NZJP publishes ML Roberts Prize-winning papers without internal peer-review.

Influences of psychological factors and rehabilitation adherence on the outcome post anterior cruciate ligament injury/surgical reconstruction

Minetta Mendonza¹, BHSc (Physio)

Hiral Patel¹, BHSc (Physio)

Sandra Bassett², PhD, MHSc (Hons), BA, Dip Phty (Otago)

At the time of writing this paper, ¹ were 4th year undergraduate students at the School of Physiotherapy, Auckland University of Technology, and are now currently employed as physiotherapists in Auckland. ² Senior Lecturer, School of Physiotherapy, Auckland University of Technology.

ABSTRACT

Objective: To systematically review research that has investigated the relationships between psychosocial factors, adherence and outcomes of rehabilitation following ACL injury/reconstruction.

Methods: A systematic literature search of the EBSCO, CINAHL, PEDro, PsycINFO and SPORT Discus databases was conducted by two of the authors independently. A critiquing tool was developed to critically evaluate the studies on the basis of their purpose, design, participants, measures and results.

Results: 117 articles were found, of which 10 met the criteria for inclusion in the review. The results of the studies point to the existence of the psychosocial-adherence and adherence-outcome relationships. Strengths of the research were the large sample sizes and the multifaceted measurement of the three variables of interest. However very few studies used longitudinal and cause-effect study designs to evaluate the variables.

Conclusion: Psychological factors in particular motivation, self-efficacy and perceptions of personal control were positively associated with adherence behaviours and rehabilitation outcomes. There were contradictory findings for the adherence-rehabilitation outcome relationship, with it being positive for young adults, but negative for older adults, which is suggestive of a dose-response effect. Future research should focus not only on the relationships between psychosocial factors, functional outcomes and adherence, but should also investigate amount of adherence required to produce optimal rehabilitation outcomes. **Mendonza M, Patel H, Bassett S (2007): Influences of psychological factors and rehabilitation adherence on the outcome post anterior cruciate ligament injury/surgical reconstruction. New Zealand Journal of Physiotherapy 35(2): 62-71.**

Key words: adherence, psychosocial factors, functional outcomes, physiotherapy rehabilitation, anterior cruciate ligament injuries

INTRODUCTION

The Anterior Cruciate Ligament (ACL) plays a crucial role in stabilising the knee thereby preventing anterior gliding of tibia on femur. Rupture of this ligament is a common injury sustained by both competitive and recreational athletes. Traditional rehabilitation programmes following surgical reconstruction of the ACL aim to return the athlete to sporting activity by nine to twelve months post-operatively (Shaw, 2002). However, over the past decade the rehabilitation programmes have been accelerated, with patients returning to normal functional activity within four to six months postoperatively (DeCarlo et al 1992).

Most physiotherapy literature and research concerning rehabilitation following ACL injury and reconstruction have focused on physical treatment, with only a small amount investigating

the psychological aspects of recovery. This has led to the emphasis on the physical aspects of the rehabilitation, with little regard to the associated psychological factors, in spite of the athletes' future sporting career goals and aspirations having been dashed. Effective injury management requires an understanding of the psychological processes involved and the knowledge of strategies that can affect healing (Crossman 1997). For example it is recognised that ideally athletes should take the responsibility for their own rehabilitation and that so long as their recovery is not problematic they will achieve successful rehabilitation outcomes, but this does not always occur. Evidence points to athletes who are motivated to undertake their rehabilitation, persist with the treatment and willing to learn are the most successful in their rehabilitation (Crossman 1997). Furthermore, those who perceive that their treatment is effective tend

to have high levels of social support, are highly motivated and adhere to treatment. Adherence to rehabilitation has also been linked to the careful monitoring of athletes' daily progress and clinical outcomes (Fisher et al 1993).

While there have been a number of reviews of the research into the influence of psychological factors on adherence and rehabilitation outcomes for sports injuries in general, these have been primarily descriptive as opposed to a systematic synthesis of the literature (see Crossman 1997, Fisher 1990, Smith 1996). Another review by Doyle et al (1998) did evaluate the literature on the psychobiological implications of ACL injuries on athletes, but it also lacked a systematic methodology. Therefore, this review systematically evaluated the research that has investigated influences of psychological factors and patient adherence to rehabilitation on the outcome post ACL injury and reconstruction.

METHODS

Data sources

The computer-supported search used the following databases: EBSCO, CINAHL, PEDro, PsycINFO and SPORT Discus. The keywords used for searching EBSCO were based on the criteria for study selection, and then modified for other databases (see Figure 1). Modification was required due to limited search options of these electronic databases, mainly with regard to variations in truncation symbols. The key words were: anterior cruciate ligament, injury, rehabilitation, psycho, and adherence.

References deemed suitable from the first wave of studies that met the inclusion criteria were then searched to trace further potential studies. Due to a limited number of researchers who have investigated the psychological effects on recovery from ACL repairs and the role adherence plays in the rehabilitation, their names were used as search terms to further identify other investigations that they undertook into the topic of interest. A manual search was done from the third author's (SB) collection of adherence studies, to complement the selection. All searches were done independently by the first two paper authors (MM and HP), who then conferred to ensure that their search strategies were reliable and valid for the topic under review.

Study selection

The studies included in the review were all articles written in English, published prior to June 2006 and reported results of the effects of psychological variables and adherence on rehabilitation outcomes following ACL injury/reconstruction in adults or adolescents. The articles were categorised into two groups, with the first being studies that assessed the psychological and adherence effects and the second being those that assessed effects of rehabilitation adherence on the rehabilitation outcome. Both groups are considered equally important to provide a complete overview of the existing evidence on

psychological factors and rehabilitation adherence on outcome post ACL injury or reconstruction.

Data extraction

The screening of the abstracts of the studies was done initially independently by each of the first two authors who then met to discuss their decisions. Where disagreement occurred over the eligibility of studies to be included in the review, the first two authors discussed the reasons for their conflicting decisions and where possible came to an agreement. If no agreement could be made, the third author (SB) was consulted who screened the papers under dispute. The eligibility criteria regarding type of study, participants, and measures were used to select the relevant studies (see Figure 1). If the abstract did not provide adequate information, the full text of the article was read and evaluated to decide whether or not to consider it as worthy of inclusion.

Study characteristics

The important study characteristics were extracted by the first two authors independently in order to investigate possible associations with the study outcomes. The studies were critiqued and evaluated on the basis of their content in the areas of their purpose, methodology including design and participants, measures, results, limitations and strengths (see Figure 1, Tables 1 and 2).

RESULTS

A total of 117 articles were retrieved from the searches of the EBSCO Health database (n = 65), CINAHL (n = 12), SPORT Discuss (n = 27), and PsycINFO (n = 13). A further 12 articles were identified through a manual search of the third author's (SB) collection of journal articles. No suitable articles were found by searching the references of the articles.

The first selection was based on title, abstract and key words. In addition to the theoretical articles, research articles were excluded if (1) participants were not primarily diagnosed with ACL injury or had other additional pathologies (for example, medial collateral ligament strain, meniscal tear, total knee replacement); (2) the purpose of the study was to determine the validity/reliability of measures; (3) the interventions focused on testing the effect of skills on outcome; and (4) any combination of the previous three exclusion criteria. This process resulted in 19 retrieved articles, of which eight were double references.

One of the remaining eleven articles was excluded because participants received counselling skills as the intervention, which influenced the psychological factors. Ultimately, seven studies met the eligibility criteria of having investigated the relationship between rehabilitation adherence and psychological influences in recovery from post ACL injury/reconstruction. Three studies that investigated the influence of rehabilitation adherence on the recovery from post ACL injury

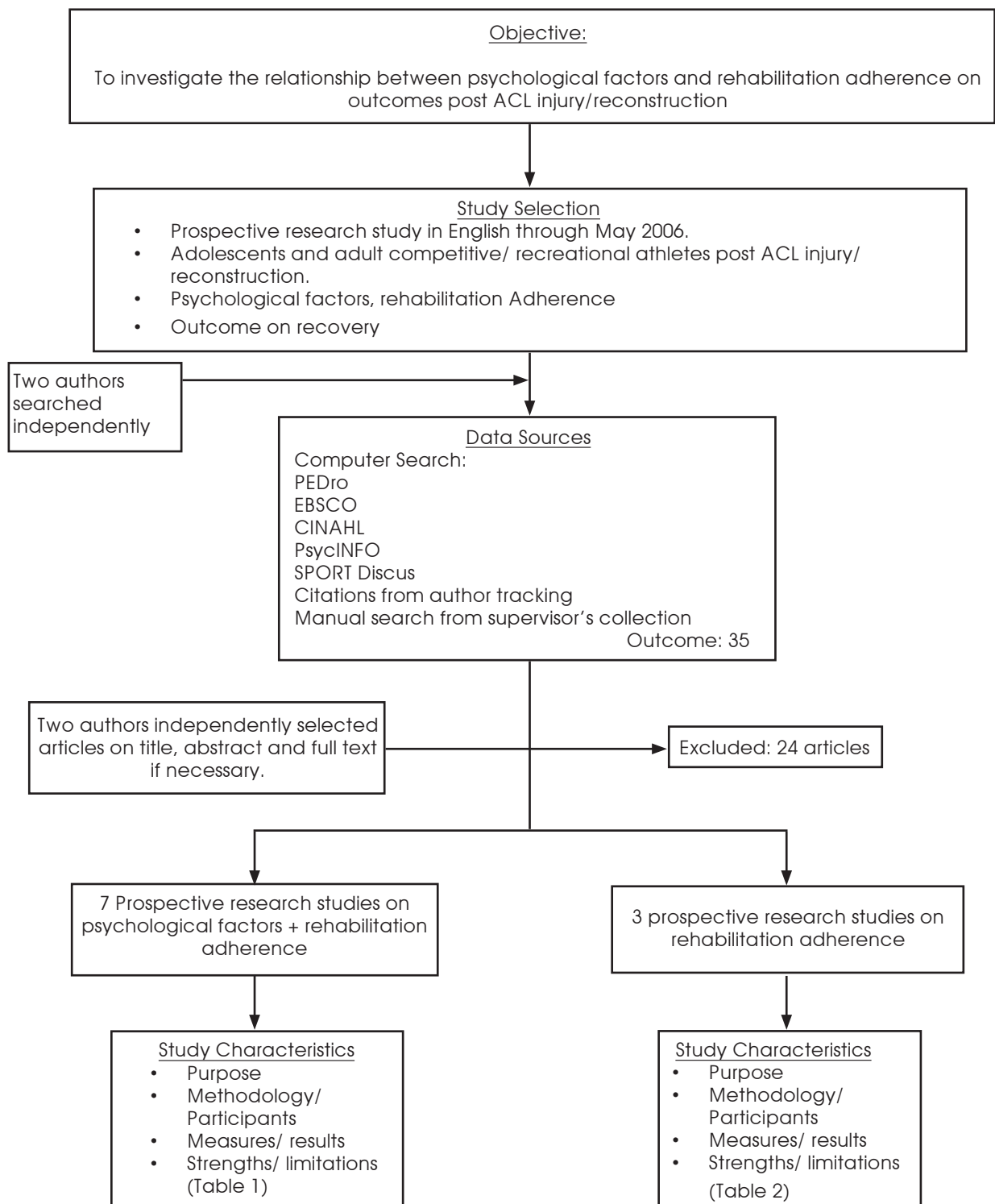


Figure 1. Overview of literature search, criteria, and classification

or reconstruction met the eligibility criteria for inclusion in the review. Overall the studies in both categories had moderate sample sizes, ranging from 143 down to 34 participants; all included both males and females, and had a mix of sportspeople and people not involved in sport.

Studies investigating psychosocial-adherence relationships

In these studies there was a raft of psychosocial variables investigated. Two of the studies undertaken

by Brewer et al. (2003, 2000b) examined the association between motivation, social support, athletic identity and clinic- and home-based adherence. Scherzer et al. (2001) took a slightly different approach to investigating the relationship between adherence and psychological factors by having the participants complete a questionnaire about the extent to which they used goal setting, imagery and positive self-talk during the initial five weeks of their post-operative rehabilitation. Another two studies investigated the relationships

Table 1. Investigations of the Relationships between Rehabilitation Adherence and Psychological Influences in Recovery from Anterior Cruciate Ligament injury/ reconstruction.

Author (Year)	Purpose	Methodology & Participants	Measures	Results	Limitations	Strengths
Brewer et al (2000b)	Investigated relationship between adherence, psychological factors and functional outcomes.	Prospective descriptive study Participants: Initial N = 95 Final N = 69 Acute ACL tear M age = 26.9 yrs	Psychological: SMI, SSI, AIMS, BSI, Adh: SIRAS, self report home exercise and cryotherapy completion. Functional: KT1000, One leg hop test, self report Lysholm Knee scoring scale.	SMI significantly predicted home exercise completion, AIMS and BSI predicted KT1000 scores, clinic attendance, SIRAS scores and home cryotherapy predicted one leg hop test.	Time frame too short, loss of power due to attrition of participants; possible biases in Adh measures; SSI is a measure of healthy people's perceived social support.	Homogeneous sample, Large range of measures.
Kvist et al (2005)	Investigated the effect of fear of reinjury on return to the preinjury level of activity.	Prospective descriptive study Participants: N = 62 3-4 yrs post ACL reconstruction M age = 27 yrs	TSK, KOOS, & questionnaires about pain and activity levels.	TSK scores predicted return to previous level of activity; and is negatively correlated with KOOS.	No attempt to rationalize for fear, No measures of knee function, validity of TSK for this study not reported.	Homogenous sample, strong power.
Udry et al (2003)	Investigated differences between adolescents & adults on psychological readiness for ACL reconstruction and preoperative mood levels	Prospective descriptive study Participants: N = 121 ACL Injury M age = 21.6 yrs. Adolescents 15-19yrs (n = 67) Adults: > 30yrs (n = 32).	Self reported mood disturbances, 10 questionnaires measuring psychological factors, decisional balance and SE.	Significant differences between adolescents and adults with 42% variance attributable to group differences.	Assessments were administered on the day of surgery, making it hard to reschedule the surgical appointment for patients who were not psychologically ready.	Appropriate age difference between groups, homogenous sample in terms of injury, multifaceted approach to psychological measurement, adequate reliability for all measures.
Brewer et al (2000a)	Investigated relationships between causal attributions and sport injury recovery rate, & Adh to injury rehabilitation.	Prospective research design Participants: N = 80 ACL rehabilitation M age = 27.2 yrs	Recovery Progress Scale, Self reported attribution for recovery on CDSII; Adh: % of clinic attendance, SIRAS	CDSII accounted for a significant variance in recovery progress ratings, $R^2 = .41$, $F(4,69) = 11.85$, $p < 0.001$	Adh for home based activities not assessed, attributions for recovery rate & CDSII only fill 5 weeks post surgery, no objective measures for physical recovery.	Homogenous population in term of surgery and rehabilitation. Appropriate statistical analysis. Multifaceted psychological measures.
Laubach et al (1996)	Examined the relationship between causal attributions for recovery & Adh to injury rehabilitation.	Prospective Correlational design Participants: N = 34 Knee injury that required surgery M age = 30.6 yrs	Recovery Progress Scale, CDSII; Adh: % of clinic attendance, SIRAS	CDSII significantly predicted SIRAS ratings ($p < 0.001$), but not attendance at rehabilitation sessions ($p > 0.05$)	Cross sectional design preclude the drawing of causal inferences, no objective measures for physical recovery, participants with knee pathologies besides ACL, poor power.	Appropriate outcome measures with proven reliability.

Scherzer et al (2001)	To investigate the relationship between self reported use of psychological skills & Adh to ACL rehabilitation.	Prospective correlational design Participants: N = 54 ACL rehabilitation post surgery M age = 28 yrs	3 sub scales of Sports Injury Survey: goal setting, healing imagery & positive self talk. Adh: % of clinic attendance, SIRAS, self reported home exercise & home cryotherapy completion	Goal setting was significant predictor of home exercise completion ($p < 0.01$), & SIRAS rating. Positive self talk positively correlated with home exercise completion.	Correlational research design precludes the relation between psychological skills & rehabilitation Adh, the use of single item scale for imagery & self talk is not optimal.	Homogenous sample in terms of surgery and rehabilitation. Multifaceted approach to Adh measurement, appropriate reliability for some measures.
Brewer et al (2003)	Assess relationship between psychological factors & rehabilitation Adh as a function of age by re-analysis of data from Brewer, et al., (2000b)	Prospective research design Participants: N = 61 Acute ACL injury M age = 26.0 yrs	Psychological: SMI, SSI, AIMS, BSI, Adh: SIRAS, self report home exercise and cryotherapy completion.	Younger participants showed positive relationship between athletic identity & home exercise completion ($p < 0.05$). Older participants showed positive relationship between home exercise completion and self motivation; & social support	Despite being prospective research, causal relationship between psychological factors & rehabilitation, Adh cannot be inferred; self report method for measuring Adh could lead to bias in findings, lack of objective measures for injury.	Homogenous sample in terms of injury, multifaceted approach to Adh & psychological factors measurements.

Adh = Adherence; ACL = Anterior Cruciate Ligament; SMI = Self-Motivation Inventory; SSI = Social Support Inventory; AIMS = Athletic Identity Measurement Scale; BSI = Brief Symptom Inventory; SIRAS = Sport Injury Rehabilitation Adherence Scale; TSK = The Tampa Scale of Kinesiophobia; KOOS = Knee Injury and Osteoarthritis Outcome Score, QOL = Quality of Life; yrs = years; % = Percentage, CDSII = Revised Causal Dimension Scale; M age = Mean Age; SE = Self Efficacy.

between causal attribution and rate of recovery from the injury and rehabilitation adherence (Brewer et al 2000a, Laubach et al 1996). As participants were asked to list the causes they believed could be attributed to their recovery, a large number of psychological factors were identified as possibly affecting rehabilitation adherence. The remaining two studies investigated the effect of fear of re-injury when returning to pre-injury level of activity and the differences between adolescents and adults on psychological readiness for ACL reconstruction (Kvist et al 2005, Udry et al 2003). Five of the seven studies employed a prospective research design, whereas the remaining two of the seven studies were prospective correlational designs (see Table 1).

Participants in the studies were recruited through local advertisements in therapy clinics, and by approaching consecutive patients scheduled for ACL reconstruction (Brewer et al 2000b, Brewer et al 2003) and ACL reconstruction database at the local hospital (Kvist et al 2005). Inclusion criteria were described in all seven studies. Inclusion criteria were: no injuries besides ACL, age 16 to 48 years, no previous ACL repairs and unilateral injury. The post injury rehabilitation phases were not defined uniformly in the separate studies.

In three studies, participants had an ACL injury, while the remaining four studies had participants who were in post-operative rehabilitation. Two studies divided the participants into two age groups to interpret the relationship between psychological factors and rehabilitation adherence as a function of age (Brewer et al 2003, Udry et al 2003). In general, the patient characteristics were not exclusively associated with better or worse outcomes (see Table 1).

While there was some variation in the use of adherence measures employed, five studies used the Sports Injury Rehabilitation Adherence Scale (SIRAS; Brewer et al 2000c). The second most common measure, percentage of clinic attendance, was used in three studies. Other studies used self-reports of home exercise and cryotherapy completion as adherence measures (Brewer et al 2000a, Brewer et al 2000b, Laubach et al 1996, Scherzer et al 2001).

A wide variety of psychological measures was used in the different studies. For example, self-motivation was measured by the Self Motivation Inventory (SMI; Brewer et al 2000b; Brewer et al 2003), Decisional Balance and Self-Efficacy scales (Udry et al 2003) and Sports Injury Survey (Scherzer et al 2001). While most of the studies lacked a functional outcome measure, Brewer et al (2000b) did use one leg hop test, KT1000, and self report Lysholm knee scoring scale.

Studies investigating adherence-functional outcome relationships

All studies investigated the relationship between adherence to rehabilitation and outcomes following reconstructive surgery of the ACL (Brewer et al 2004,

Table 2. Investigations of the Relationship between Rehabilitation Adherence and the Functional Outcomes following the Rehabilitation of Anterior Cruciate Ligament Injury/Reconstruction.

Author	Purpose	Methodology & Participants	Measures	Result	Limitations	Strengths
Pizzari et al., (2005)	To examine the relationship between Adh to rehabilitation & outcomes following ACL surgery	Prospective design Participants: N = 68 ACL rehabilitation post surgery M age = 28.8 yrs	Adh: % of Clinic Attendance, SIRAS, self reported home exercise completion; IKDC, 6-min timed hop test, triple cross over hop test, Questionnaires: Subjective section of IKDC, CKRS (4 scales), KOOS	Significant relationship between home exercise completion & improved outcomes for participants less than 30 yrs of age. Two significant -ve correlations between Adh to home exercises & knee function in participants 30yrs or older	Unstructured data searching to identify confounding variables, self report diaries for home exercise completion could have led to bias in the findings	Homogenous sample in terms of surgery, multifaceted approach to Adh measurement & treatment outcomes
Feller et al., (2004)	To examine whether minimal PT attendance could result in a satisfactory outcome post-ACL reconstruction	Pilot study (retrospective patient selection, prospective assessment) Participants: N = 143, short listed to 20 ACL injury M age = 27.95 years	Adh: Attendance to PT clinics (by telephone interviews and database records). Outcome measures: CKS, CORs, CSAL, IKDC; active and passive knee ROM, anterior knee laxity (KT-1000 arthrometer)	Higher scores on the symptoms subscale of the CKS in the minimal PT group ($p=0.045$), tending towards significantly higher overall CKS score ($p=0.06$). No significant between-group differences found for any other measure.	Retrospective patient identification (difficult to control for confounding variables); small sample size due to it being a pilot study; convenience sample increased likelihood of bias. Moreover, effects of a non-clinic based rehabilitation programme were not considered and study lacked pre- and post-surgery assessment.	Assessors were blinded to the Adh scores of participants, decreasing bias. Clear demarcation between Adh groups increased validity of results. Homogenous sample (surgical repair of ACL injury).
Brewer et al., (2004)	To examine the relationship between Adh to post-op PT and outcomes after surgical ACL repair.	Prospective study Participants: N = 108 ACL injury M age = 29.38yrs	Adh: % of clinic attendance, self-report of HEP completion, electronic counter on PreP video, SIRAS. Outcome measures: Lachman test (knee laxity), 1-leg hop for distance, KOS-SAS questionnaire.	The three Adh variables correlated with the three outcome measures ($p<0.05$), clinic Adh correlating to fewer self-reported symptoms, but increased knee laxity. Low pre-surgical KOS-SAS scores corresponded with high 1-leg hop scores ($p<0.05$). Clinical Adh correlated negatively with home exercise completion ($p<0.005$).	No detailed outline of inclusion criteria and patient demographics, decreasing internal and external validity. Use of self-report diary could lead to bias of findings. Battery malfunction in the electronic counter could result in falsely -ve adherence results. Main analysis of data was by correlation method.	Multifaceted approach to rehabilitation and adherence measurement, especially incorporation of an objective measure of home adherence. Conducting assessments pre- and post-rehabilitation completion enabled comparing results over time.

Adh = Adherence; ACL = Anterior Cruciate Ligament; yrs = years; SIRAS = Sports Injury Rehabilitation Adherence Scale; IKDC = The International Knee Documentation Committee; CKRS = Cincinnati Knee Rating System, KOOS = Knee Injury and Osteoarthritis Outcome Score; PreP = Personalised Rehabilitation Programme; HEP = Home exercise programme; KOS-SAS = Knee Outcomes Survey – Sports Activities Scale; CKS = Cincinnati Knee Score; Cincinnati Occupational Rating Scale; CSAL = Cincinnati Sports Activity Level; ROM = Range of motion; -vely = negatively; post-op = post-operative.

Feller et al 2004, Pizzari et al 2005). One study used a prospective cohort design to investigate the adherence-outcome relationship over an eight-week period and extended the analysis of the relationship to include a comparison on the basis of age (Pizzari et al 2005). Another employed a prospective correlational design to investigate the association between adherence variables (adherence to home-based and clinic-based rehabilitation) and outcome variables over a six-week period (Brewer et al 2004).

The Feller et al (2004) study was a pilot, with the participants being selected from a database of patients who had undergone ACL repairs. They were categorised according to the number of physiotherapy treatment appointments they had attended during the first six months after surgery into minimal (three or fewer attendances), intermediate (four to 11 attendances) and regular physiotherapy (12 or more attendances). To establish whether the level of attendance had an effect on the treatment outcomes, the outcomes of the minimal attendees were compared with those of the regular attendees.

People about to undergo ACL reconstruction with follow-up post-operative physiotherapy rehabilitation were recruited through their orthopaedic surgeon (Feller et al 2004, Pizzari et al 2005), or by the research project personnel (Brewer et al 2004). All three studies outlined inclusion and exclusion criteria (Brewer et al 2004, Feller et al 2004, Pizzari et al 2005). Participants recruited in all studies were undergoing rehabilitation following the ACL reconstruction. The age group ranged from 14 to 54 years and included both males and females. Baseline demographics and patient characteristics were not shown to predict patient outcomes. One study compared the participants' outcomes on the basis of their age, namely those younger than 30 years and those 30 years and older (Pizzari et al 2005). See Table 2 for more details about the participants.

A variety of tools was used in the three studies to measure demographics, injury-related information, adherence, and rehabilitation outcomes. While the tools used to measure adherence differed among the studies, the SIRAS was used in two (Brewer et al 2004, Pizzari et al 2005) and physiotherapy clinic attendance was monitored in all (Brewer et al 2004, Feller et al 2004, Pizzari et al 2005). Outcome measures included functional measures, knee range of motion (ROM) and laxity measures, such as the International Knee Documentation Committee (IKDC) form (Feller et al 2004, Pizzari et al 2005) and the one-leg hop test (Brewer et al 2004). Subjective symptoms were monitored by Cincinnati Knee Rating System (CKRS) (Pizzari et al 2005), Knee Outcomes Survey-Sports Activities Scale (KOS-SAS; Brewer et al 2004) and the Cincinnati Knee Score (CKS; Feller et al 2004).

DISCUSSION

This systematic review found evidence of psychological factors and rehabilitation adherence

affecting the outcomes following ACL injury/rehabilitation, although relatively few of these studies involved people with ACL injuries. It was also notable that a range of psychological factors and functional/treatment outcomes was measured.

Studies investigating psychosocial factors-adherence relationships

There is general consensus that psychological and social factors play an important role in recovery from an injury, sports-related or otherwise. These factors extend to adherence rates and clinical outcomes as well as the effectiveness of coping mechanisms. The two studies (Brewer et al 2000a, Laubach et al 1996) that investigated the participants' causal attributions found that those who considered they had a rapid rate of recovery gave more stable and personally controllable reasons for their recovery than those who thought they had a slower rate of recovery. However the associations between causal attributions and adherence were different in these two studies. Brewer et al (2000a) found that the causal attributions predicted clinic attendance, but not adherence during clinic treatment, whereas Laubach et al (1996) had the opposite pattern of findings. Brewer et al (2000a) reasoned that this could have been due to the slightly different timing of adherence measures in the studies, with their measurements being taken in from the third to the 12th week post-operative, and those of Laubach et al (1996) being taken during the first four weeks following surgery. The similarities in the causal attributions could well have been due to the similar participant populations and measures used.

Adherence to home exercises was significantly predicted by goal setting and positive self-talk, and goals were also significant predictors of adherence to the clinic treatments (Scherzer et al 2001). Positive self-talk was interpreted as a means of the participants remaining motivated during their rehabilitation and goals as a way of their remaining focused throughout it, with both being seen as methods of taking personal control for their recovery (Scherzer et al 2001).

Fear of re-injury, an important factor among athletes, hindered return to previous activity levels, and was correlated with low knee-related quality of life (Kvist et al 2005). Self-motivation was a significant predictor of home exercise adherence (Brewer et al 2003; Brewer et al 2000b; Scherzer et al 2001) which in turn enhances functional outcomes (Brewer et al 2000b). In different age groups, motivation may play a diverse role with respect to patient response to rehabilitation (Brewer et al 2003). For example, younger participants showed positive relationships between athletic identity and some exercise completion, whereas older participants with higher self-motivation showed greater adherence (Brewer et al 2003). Similarly, Udry et al (2003) found significantly higher levels of psychological readiness for ACL reconstruction in adolescents compared with adults over 30 years.

Irrespective of age, psychological readiness was linked with higher levels of self-efficacy.

Despite there being no noteworthy disparities among the studies findings, there were differences in the psychological factors measured and measurement tools, hence making it difficult to compare the studies. Moreover, some of the outcome measures were inappropriate to the participant population. For example, the KOOS questionnaire is designed for an osteoarthritic population (Kvist et al 2005), whereas the TSK is specially designed for people with back problems (Crombez et al 1999, Kvist et al 2005), and the SMI and SSI are for use with non-clinical populations.

Studies investigating adherence-functional outcome relationships

With regard to the relationship between rehabilitation adherence and functional or symptomatic outcomes, two studies found that higher rates of adherence correlated with improved outcomes (Brewer et al 2004, Pizzari et al 2005). These two studies had similar patient groups (age, gender, and injury), and physiotherapy rehabilitation programmes. Brewer et al (2004) found that clinic attendance was linked with adherence to clinic treatment and decreased symptoms, but negatively correlated with adherence to home exercises. The authors interpreted the two relationships between attendance and adherence as being indicative of the participants being inclined to focus either on their clinic treatment activities or home exercises, but not necessarily on both forms of treatment. Hence those who focused on the home exercises were poor at attending their clinic appointments. In contrast, Pizzari et al (2005) found that positive outcomes were mainly predicted by adherence to home exercises, not adherence to the components of clinic treatment.

The findings of Feller et al (2004) also pointed to home based adherence to rehabilitation following ACL reconstruction playing a more important role in treatment outcomes than clinic attendance. This was based on their findings of the levels of clinic attendance making no difference to outcomes; although ironically, poor adherers fared marginally better. Interestingly, Brewer et al (2004) also noted that highly adherent individuals had greater ligamentous laxity at nine and 12 months post-reconstruction. A possible interpretation for this finding is that too much activity may not be conducive to tissue healing. Pizzari et al (2005) expressed similar concerns as a consequence of their findings of a significant positive correlation between adherence and outcomes in the participants under the age of 30 years, whereas for those 30 years and older higher levels of adherence were significantly related to poorer treatment outcomes. Disparities in results across these three studies could be due to the different measurement tools used, as well as variations in the timing of application of these measures.

Strengths and limitations of the reviewed studies

The strengths of the studies were primarily their use of homogenous sample, relatively large sample sizes, prospective study designs, and multifaceted psychological measures with proven reliability. Some of the limitations were short study duration, participant attrition, lack of functional outcome measures, intervention procedures, the use of self reports to measure adherence, which may predispose to bias, and using psychological measures designed for non-clinical populations. Moreover, studies investigating adherence-outcome relationships largely used correlational as opposed to cause-effect analyses, decreasing the strength of their findings. Because of these limitations caution needs to be taken when interpreting study results.

Clinical implications

The post-operative rehabilitation protocols place a high demand on patients, which for some appear to have adverse effects, as happened with the older participants in the Pizzari et al (2005) study. There is evidence to suggest that these adverse effects could be due to the changes in soft tissues that occur with aging (Wilmore and Costill 1999). Ligaments and cartilage are avascular tissue and have similar healing rates that are slower than vascularised tissue (Moore and Dalley 2006). Different meniscal healing rates have been reported for patients under and over 30 years following knee reconstruction that includes ACL repairs (Tenuta and Arciero 1994). Furthermore, Tenuta and Arciero (1994) demonstrated that patients undertaking a "conservative" rehabilitation programme consisting of limited weight bearing and range of motion for the first six weeks post surgery demonstrated a higher rate of completely healed menisci than did participants undertaking an accelerated protocol. Moreover, Cole and Malek (2004) indicated that with ACL tears, the involvement of meniscal damage or increasing age was linked with slowed healing rates. Hence, the accelerated programmes appear contrary to established healing rates for ligaments, and this aspect should also be taken into account with patients who are not responding as expected. The age and physical status of a patient should be considered when prescribing ACL rehabilitation, and it appears that older patients benefit from a slower rate of progression through the rehabilitation programme. Nonetheless, the accelerated programme has been proven effective for younger adults and should be considered the main form of rehabilitation for these people.

Psychosocial factors such as fear of re-injury, self-efficacy, treatment efficacy, motivation and social support play an important role in recovery from an ACL injury. Practitioners should focus in particular on ways of enhancing self-efficacy and motivation as these seem to be the most influential

(Pizzari et al 2002). In older patients, it might be necessary to promote readiness for reconstructive surgery and higher self-efficacy in order to optimise rehabilitation outcomes.

Recommendations for future research

Most previous research has focused on the rehabilitation of young adults following ACL repair, to the detriment of older people. Future research should employ cause-effect designs to compare the effects of traditional, medium-paced and accelerated rehabilitation programmes on younger versus older populations. To some extent this type of research would also shed light on the dose-response and ultimately how much adherence is required to obtain an optimal rehabilitation outcome. Such studies should have sample sizes that provide the study with the power to show whether there are significant differences between the different rehabilitation programmes. The measures for adherence and treatment outcomes should be multifaceted, and the psychological measures should be suitable for clinical populations. Finally research should incorporate tools to assess the healing status of the ligament.

Strengths and limitations of this review

Strengths of this review were the use of systematic search strategies, specific criteria for study selection, wide range of databases and searching systems, and no restrictions on the literature timeframes, thereby permitting a wide range of literature to be sought. One of the limitations was that the search was restricted to articles published only in English. One should also consider possible publication bias. Small studies with a non-significant outcome typically remain unpublished, and therefore the true extent of the relationships between adherence, psychological variables and treatment outcomes could not be fully investigated. Finally we acknowledge that in spite of undertaking an extensive search of the databases we may have missed research that would have been appropriate for this review.

CONCLUSION

The findings of this review indicate that there is interplay between psychological factors, adherence and functional outcomes. In particular motivation, a sense of personal control, social support, self-efficacy and fears about re-injury do have an impact on rehabilitation adherence. It appears that these psychological characteristics can be bolstered by the use of treatment goals and positive self-talk (Scherzer et al 2001). While there were significant relationships between adherence and treatment outcomes, these were contradictory, which could be a consequence of slower rates of soft tissue healing in older adults, and should be interpreted as a dose-response. Physiotherapists should take into account the age and physical and psychological status of their patients when prescribing a rehabilitation programme following

surgical ACL repair. It appears that older adults would benefit for a slower rehabilitation protocol in terms of their rehabilitation outcomes, but with the use of psychological readiness the older patients might fare better post-operatively. While the evidence points to some clear links between psychological factors and adherence, further research is required to clarify these links and the circumstances under which they operate. Given the contradictory nature of the findings for the adherence-rehabilitation/functional outcome relationships, more investigations are required into these; in particular it is not known how much adherence is required to produce optimal functional outcomes for the patients following ACL injury/reconstruction.

Key Points

- Following ACL injury/reconstruction, motivation, personal control, self-efficacy and fears about re-injury are significantly associated with rehabilitation adherence.
- The adherence-functional outcome relationship is inconsistent and appears to be either age related or dose-response dependent.
- When prescribing a rehabilitation programme following ACL reconstruction physiotherapists should take into account the patients' age, and psychological and physical status.
- Future research is required to establish the dose-response for rehabilitation following ACL injury/reconstruction.

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ADDRESS FOR CORRESPONDENCE

Dr Sandra Bassett, School of Physiotherapy, Auckland University of Technology, Private Bag 92206, Auckland 1142, New Zealand. E-mail: sandra.bassett@aut.ac.nz Phone: 099219999 ext 7123. Fax: 099219620

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