The Effect of Decline Loading on Patellar Tendinopathy in Rugby Union Players

Mark Plummer

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Primary Supervisor: Professor Wayne Hing

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Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgments), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or institute of higher learning."

Mark Plummer

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Ethical Approval

This research was approved by the Auckland University of Technology Ethics Committee (AUTEC) on the13/01/2012. Reference: 11/326.

Abstract

Objective: The objective of this study was to investigate the effect of an Eccentric Decline Squat (EDS) programme in a rugby player population with Patellar Tendinopathy. It was hypothesized that implementing an EDS programme of 12 weeks duration, with this target population, will give improved VISA-P (Victorian Institute of Sport Assessment) outcome results than a standard treatment regime.

Study Design: An interventional study design was used, comparing the effectiveness of an EDS programme to alternate treatment regime in 28 rugby union players, who continued to train and play.

Background: Patellar tendinopathy is a common condition in athletes, and often difficult to resolve. Several recent studies have shown promising clinical results using single-leg eccentric squat training on a 25 degree decline board to treat patellar tendinopathy. There have been no such studies on a rugby union population. The purpose of this study was to assess the effectiveness of the EDS programme in rugby players with patellar tendinopathy, and compare that with treatment regimes that did not include eccentric decline squats.

Method: Change in pain and function were recorded weekly for each group, using VISA-P scoring. The intervention group performed EDS programme on a 25 degree decline board, twice daily (3 sets of 15 reps), 6 days / week, for 12 weeks. The control group followed a treatment regime prescribed by their physiotherapist, for 12 weeks. Their regime did not

include eccentric decline squats as part of the management. Players in both groups continued to train and play rugby throughout the intervention period.

Results: Following the intervention period there was a significant (p=.000) improvement in VISA-P scores for the intervention group from the baseline to the 12 week mark, 65.75 points (SD 9.08) to 94.5 points (SD 10.02). No significant differences (p=.900) were observed in the control group with regard VISA-P scores, 66.75 (SD 15.49) to 81 points (SD 18.33).

Conclusion: This is one of the first research studies looking at an EDS programme in a rugby population. The results in this study showed EDS offered greater gains than other standard care treatment options over a 12 week period.

The results of this study will support, and recommend, future use of EDS in a rugby population with this injury. Further studies involving greater numbers and comparing EDS to other treatment programmes, as in this study, may add weight to these findings.

1.0 Introduction

1.1 Statement of the problem

Patellar tendinopathy, commonly referred to as Jumpers knee, is an injury with a high prevalence in athletes (Visnes & Bahr, 2007). Some studies put the prevalence of jumper's knee at 40-50% among elite volleyball players (Visnes & Bahr, 2007; Young, Cook, Purdam, Kiss, & Alfredson, 2005). Clearly this figure will differ with different sports. A recent study looking at 83 elite academy rugby players put the prevalence of patellar tendinopathy at 9.6% (Durcan et al., 2014).

Patellar tendinopathy is often seen in jumping sports such as basketball, volleyball, high jump and long jump. Athletes often describe their symptoms as a sharp or stabbing pain localised to the patellar tendon during exercise, but in severe cases athletes describe a more consistent dull ache immediately post exercise (Visnes & Bahr, 2007).

Many athletes present themselves to physicians and physiotherapists when they are symptomatic. This presentation may be precipitated by a temporary increase in tendon loading, and in a proportion of patients, the symptoms will inevitably settle spontaneously, only to reoccur later; thus, a cyclical pattern of symptoms and remission is not uncommon (Scott et al., 2013).

Tendon pain is generally well localised with little referral beyond the tendon, unless there is extensive involvement of the associated bursa or fat pad (Kountouris & Cook, 2007).

This tendon pain is provoked by loading; the greater the load the more pain is experienced. This pain has a very short latency, experienced only when load is applied and abating quickly on removal of provocation (e.g. hopping) (Cook & Purdam, 2013).

June et al (2006) suggested it is unusual for a tendon to trigger pain without load, or to be painful at night or at rest, though Cook et al (2013) found no consensus on why some tendons are painful and others are not.

Tendinopathy begins with a mismatch between the tendon's load capacity and load placed on the tendon, most commonly through a sudden and/or substantial change in the load (Cook & Purdam, 2013). It has been suggested the maxim that 'tendons don't like rest or change' should be instilled in athletes with a propensity for tendinopathy (Cook, as cited in Scott et al., 2013, p. 439).

The management of patellar tendinopathy is not as defined as achilles tendinopathy, and although studies are suggestive of a role for eccentric loading, it appears to still lack an obvious treatment choice (Cook et al., 1997). Further, an explanation for the pain mechanism associated with tendinopathy remains unclear. However, neovascularisation has been suggested as one possible explanation (Cook & Malliaras, 2004; Ohberg & Lorentzon, 2001).

To date, conservative management of patellar tendinopathy has included combinations of rest, exercise, ultrasound, heat, ice, frictions, biomechanical adjustments, and medication (Cook & Khan, 2001). Often, in the acute phase of treatment, reduction of risk factors such as training errors, flexibility issues and biomechanical abnormalities have also been suggested (Woodley, Newsham-West, & Baxter, 2007).

Tensile strength has been reported as necessary to orientate collagen fibres, and stimulate tendon load bearing capacity. Further, exercise has been shown to increase the growth factor 1 tendon fibroblasts, and stimulate collagen synthesis and cellular reproduction (Khan & Cook, 2000). Previous studies have shown both healthy and injured tendons

respond to controlled progressive stress, resulting in increased tensile strength (Kongsgaard et al., 2006).

Eccentric squat training has gained popularity with positive short term clinical outcomes (Jonsson & Alfredson, 2005; Purdam et al., 2004). Forms of eccentric exercise have been shown to facilitate collagen production in abnormal tendons (Cook & Purdam, 2009), and other studies conclude eccentric exercise to be beneficial for pain reduction, improvement in function, and return to activity with common tendinopathies (patellar, achilles and elbow) (Bahr, Fossan, & Loken, 2006; Woodley et al., 2007).

Rugby started as a game in 1823 at Rugby School, England, and has since evolved into a sport played by more than 3 million people in more than 100 countries around the world (Brooks & Kemp, 2008). Rugby is characterised as a contact sport, and players must also be skilled at running, jumping and acceleration, along with cutting and swerving movements. They are exposed to vigorous tackling from their opponents and heavy falls to the ground, often with other players on top of them.

In 1995 Rugby Union turned professional, and in New Zealand is now played most months of the year. Since that time the game has evolved with players becoming bigger and faster. Professional full-time training has resulted in increased player skill, strength, power, and fitness, as well as increasing the body mass. Defensive systems have become more elaborate, with specialised coaches dedicated solely to that role, hence greater impacts, and an increase in injuries (Brooks & Kemp, 2008).

The Accident Compensation Corporation of New Zealand (ACC) put the cost of knee injuries in New Zealand sport at $NZ72 million in the year to June 2012. The cost of knee injuries from rugby alone was $NZ13.1 million (18% of total cost). A worrying

trend is that there were almost 1500 more knee injury claims in rugby, and over $NZ2 million more spent than the corresponding period in 2008. Costs and the number of claims have continued to rise for knee injuries over the 5 year period of these figures. However, no data specific to patellar tendon injuries was available. (Source: www.acc.co.nz).

The incidence rate of rugby match injuries reported in the literature for different demographics are; Women (3.6-7.1 injuries/1000 player hours), Schoolboys (7.0-28/1000 player hours), Senior Amateur (15-74/1000 player hours), and Professional players (68-218/1000 player hours) (Brooks & Kemp, 2008). At the last Rugby World Cup, 2011 in New Zealand, 20 nations competed and the incidences of injuries were 89.1/1000 player-match-hours. In contrast, the same tournament in 1995 had 32/1000 player-match-hours (Fuller, Sheerin, & Targett, 2013).

It is the belief of this author that the forces transmitted through the patellar tendon in rugby union are similar to those sports historically studied, and are further discussed in section 2.2.1 Jumping, squatting, stop/start, change of direction, and cumulative running load all have potential to contribute many lost hours to rugby trainings, and games. To date, no studies have been found that look at a tendon rehabilitation programme in a rugby population.

1.2 Purpose of the study

To investigate the effectiveness of an Eccentric Decline Squat (EDS) programme in a rugby player population with Patellar Tendinopathy. At this time there appears to be no research that has specifically targeted a rugby player population with this condition. It

was hypothesized that trialling an EDS programme of 12 weeks duration, with this target population, will give better VISA-P outcome results than alternative treatment regimes.

1.3 Significance of the study

The study will explore the effectiveness of an EDS intervention programme in a rugby population, which has not previously been studied as a treatment and rehabilitation option for patellar tendinopathy. It is intended that the results of the study will assist rugby players, medical staff, trainers and coaches to manage more effectively, an injury that often requires significant time away from training and playing the game.

2.0 Literature Review

2.1 Introduction

This chapter begins with the anatomy of the patellar tendon, a review of the biomechanical forces contributing to patellar tendinopathy, followed by an overview of tendon pathology.

The next sections will introduce a proposed new model of tendon pathology, followed by a summary of different treatment options offered for this condition. Finally, a review of the literature looking at studies that have used eccentric squat loading as an intervention for patellar tendinopathy.

2.2 Patellar Tendon Anatomy and Biomechanics

The patellar tendon extends from the inferior pole of the patella, as an extension of the quadriceps femoris muscle, to the tibial tuberosity. The quadriceps tendon connects rectus femoris, vastus intermedius, vastus medialis, and vastus lateralis to the patellar. The tendon inserts on the proximal pole of the patella and continues distally as a tendinous expansion over the anterior patella to merge with the patellar tendon; most of the fibres anterior to the patella are a continuation of the rectus femoris tendon (Khan, Maffulli, Coleman, Cook, & Taunton, 1998).

The tendon is well vascularised through an anastomotic ring which lies in the thin layers of loose connective tissue covering the dense fibrous expansion of the rectus femoris. The main contributory vessels are the medial inferior genicular, lateral superior genicular, lateral inferior genicular, and the anterior tibial recurrent artery (Vincentini & Khan, 1998). It has been reported that although the distal attachment of the patellar tendon to

the tibial tuberosity includes an avascular zone between ligament and bone, the proximal attachment abuts the inferior half of the patellar and the infrapatellar fat pad, both of which are richly vascularised (Scapinelli, 1968).

2.2.1 Biomechanical Contributions to Patellar Tendinopathy

Many studies have looked at biomechanical factors contributing to patellar tendinopathy which suggest multiple risk factors. Malliaris et al (2006) suggested reduced ankle dorsiflexion range, specifically athletes with less than 45 degrees of ankle dorsiflexion with a weight bearing lunge test, appear to have a greater risk of patellar tendinopathy. The coupling between ankle dorsiflexion and eccentric contraction of the calf muscle is important in absorbing lower limb force when landing from a jump, and therefore reduced ankle dorsiflexion range may contribute to an increased risk of patellar tendinopathy.

In sports with repetitive jumping and landing, athletes place large loads on their knee extensor mechanism, including the patellar tendon. Studies that have looked at these loads and forces suggest these to be major extrinsic risk factors leading to patellar tendinopathy (Cook, Khan, Kiss, & Griffiths, 2000; Ferretti, Ippolito, Mariani, & Puddu, 1983; Lian & Holen, 1996; Richards, Ajemian, Wiley, & Zernicke, 1996). Richards et al (1996) suggested that increased knee flexion during landing from a jump was a strong predictor of patellar tendinopathy, where athletes with patellar tendinopathy land with more knee flexion at initial contact. Another study looking at volleyball players suggested patellar tendinopathy symptoms may well increase relative to an increased volume of jump training (Ferretti, 1986; Ferretti & Puddu, 1984).

High vertical ground reaction forces have been found to be a predictor of patellar tendinopathy (Richards et al., 1996). Edwards et al (2012) indicated that the horizontal landing phase of a stop-jump movement places the highest load on a patellar tendon, which may potentially lead to patellar tendinopathy. The higher patellar tendon loads sustained during the horizontal landing phase are thought to be caused by limited ankle dorsiflexion, greater hip and knee flexion and utilisation of the stretch-shortening cycle during the horizontal landing phase compared with the vertical landing phase.

Other studies have found that athletes with a greater jump height ability were more likely to be affected by patellar tendon injury (Cook, Kiss, Khan, Purdam, & Webster, 2004; Lian, Engebretson, Ovrebo, & Bahr, 1996). Cook et al (2004) demonstrated that reduced sit and reach test, a measure of low back and hamstring flexibility, was also associated with patellar tendon injury.

It has also been reported that athletes with unilateral patellar tendinopathy have a longer tibia length relative to stature (Gaida, Cook, Bass, Austen, & Kiss, 2004). There is also evidence that an increase in both tibial and femoral lengths are associated with overuse knee injuries (Dahlstrom & Kujala, 1990).

There appears to be a correlation with training volume and frequency and the development of patellar tendinopathy, which studies suggest as the reason elite athletes may be more likely to develop patellar tendinopathy than recreational athletes (Ferretti et al., 1983; Gaida et al., 2004; Khan et al., 1998; Lian & Holen, 1996). It has been found that athletes participating in more than 3 training sessions per week were more susceptible to patellar tendinopathy than those participating in less than 3 training sessions per week (Ferretti & Puddu, 1984). Ferretti et al (1993) demonstrated that the

number of years of athletic competition, in this case volleyball, is also associated with patellar tendon injury.

Studies have shown that in running, which is usually the standard of reference in sport studies, ground reaction forces (GRF) are approximately 3 times body weight in the vertical direction, 0.5 times body weight in the antero-posterior direction, and less than 0.25 times body weight in the medio-lateral direction (McClay et al., 1994). Basketball player's jump on average 70 times per game and the vertical component of each GRF in a jump is around six to eight body weights. Cut and shuffle movements resulted in up to 1.6 body weights in the cut medio-lateral GRF, and 2 body weights in the shuffle medio-lateral GRF (McClay et al., 1994). Thus, sports activities can impose stresses high enough to cause fibre failure in the patellar tendon.

A force of 0.5 kN (kilo Newton) is experienced in level walking, and forces within the patellar tendon may reach 8 kN during landing from a jump, up to 9 kN during fast running, and 14.5 kN during competitive weight-lifting (about 17 times bodyweight).

Whilst we couldn't find specific literature regarding forces on rugby players and patellar tendinopathy, it is our thinking that similar forces, and the aforementioned variables, may be similar in rugby to other sports studied.

Injury occurs when the tendon fails to adapt to the onset of load and many factors have been speculated as to the reason for tendon failure (Hunter, 2000). A vicious cycle of tendinopathy leading to tendon re-injury exists (Figure 1). The tendon either adapts to loading or does not repair adequately. When loading causes micro-damage, tenocytes must increase collagen and extra cellular matrix production (further discussed in 2.3 Patho-anatomy). If a tendon is given inadequate time to repair, tenocytes may die as the

result of excessive strain. Collagen and matrix synthesis is then further reduced, making the remaining tissue even more vulnerable to damage. It is common for tendinopathies to present this way as a result of increased loading (Cook, Khan, & Purdam, 2001)

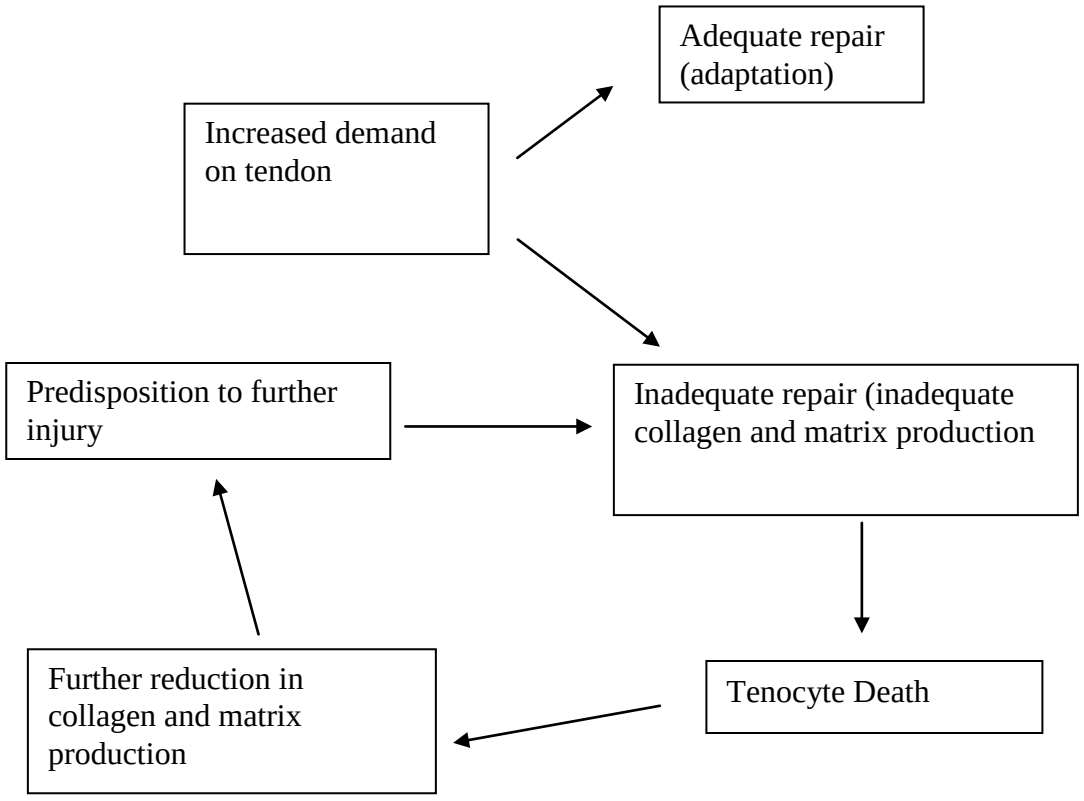

Figure 1. The Tendinosis Cycle

(Khan, et al., 1998)

2.3 Patho-anatomy

Tendons transmit load through an organised extracellular matrix composed mainly of Type 1 collagen. This matrix becomes damaged in the pathological state. The four main

components of tendon pathology include deterioration of the collagen bundles, an increase in ground substance, activation of the cellular components and vascular proliferation (Jozsa & Reffy, 1990).

2.3.1 Collagen Fibres

Khan et al (1999) reviewed the histopathology of tendinopathies, including patellar tendinopathy. Macroscopically, patellar tendinopathy contains soft yellow-brown, disorganised tissue, and on light microscopy tendons lose their typical structure of tightly bundled parallel collagen fibres.

Collagen is affected by the disruption of the fibres (transverse disruption), or bundles (longitudinal separation), with the resulting gap filled with excess ground substance (Jozsa & Reffy, 1990). These clefts in collagen suggest microtearing (Khan et al., 1998). The longitudinal separation of collagen decreases the number of cross-links between fibres, which together with a loss of fibre continuity creates a significant decrease in the strength of the tendon (Eyre & Paz, 1984).

2.3.2 Ground Substance

Ground substance is a complex mixture of proteoglycans and glycoproteins surrounding the collagen fibres. It has a high viscosity that provides the structural support, lubrication, and spacing of the fibres essential for gliding and cross-tissue interactions (O'Brien, 2005). Water makes up 60-80% of the total weight of the ground substance and in tendinopathy there is both a large increase in ground substance, and a change in the type

of proteoglycan present. In tendinopathy, the small dermochondran sulphate of a normal tendon is replaced by a larger chondroitin sulphate proteoglycan (Benazzo & Stennardo, 1996).

2.3.3 Cellular Components

There are two types of cells in a tendon: tenocytes and fibroblasts. Tenocytes are flat, tapered cells sparingly distributed among collagen fibrils. They are involved in synthesising both ground substance and protein pro-collagen building blocks (Khan, Cook, & Bonar, 1999). Fibroblasts are the primary cellular component of connective tissue. They have well developed rough endoplasmic reticulum on which the precursor polypeptides of collagen, elastin, and glycoproteins are synthesised (O'Brien, 2005).

In tendinopathy, tenocytes lose their shape. There is an increase in cellularity due to the presence of fibroblasts (Peers & Lysens, 2005). Tendon cells become active and produce both collagen and ground substance, presumably in an attempt to repair the tendon. Inflammatory cells have been found to be absent in tendinopathies.

Khan et al (1998) reported on two papers, co-authored by specialist pathologist authors who analysed all specimens in each study. They demonstrated the total absence of inflammatory cells in tissue from patients with jumper’s knee, even at the periphery of abnormal tissue, and in patients who had only had symptoms for four months. Fibroblasts however, were more plentiful than in the normal tendon, and these may have appeared to be inflammatory cells to earlier authors (Khan et al., 1998). Other authors also suggest that the former reports on signs of inflammation may have been a misinterpretation of degenerative aspects of tendinosis (Peers & Lysens, 2005).

Khan et al (1998) suggested that in most cases, the tendons of patients suffering patellar tendinopathy appear to have a tendinosis, a degenerative condition that would be expected to heal more slowly than an acute inflammatory condition. Histological findings would show non-inflammatory intratendinous collagen degeneration with fibre disorientation, hypocellularity, scattered vascular ingrowth and occasional local necrosis or calcification. Thus, sudden repeated tensile overloading may cause microtearing and fraying of tendon fibres followed by focal degeneration, particularly at the tendon insertion to the patella.

2.3.4 Vascular Proliferation

Normal tendons appear white, as they are relatively avascular. In the pathological tendon, several studies have shown abnormal small vessel in-growth (Ferretti et al., 1983; Terslev & Qvistgaard, 2001; Weinberg, Adams, & Hollenberg, 1998).

The use of colour or power Doppler Ultrasound has demonstrated vascularity, known as neovessels, in the area with structural tendon changes in patients with Jumper's knee (Terslev & Qvistgaard, 2001; Weinberg et al., 1998)

Figure 2 is a longitudinal colour Doppler sonogram of a left patellar tendon from this study, showing evidence of neovessels and increased blood flow in the proximal tendon that corresponds to an abnormal hypoechoic zone.

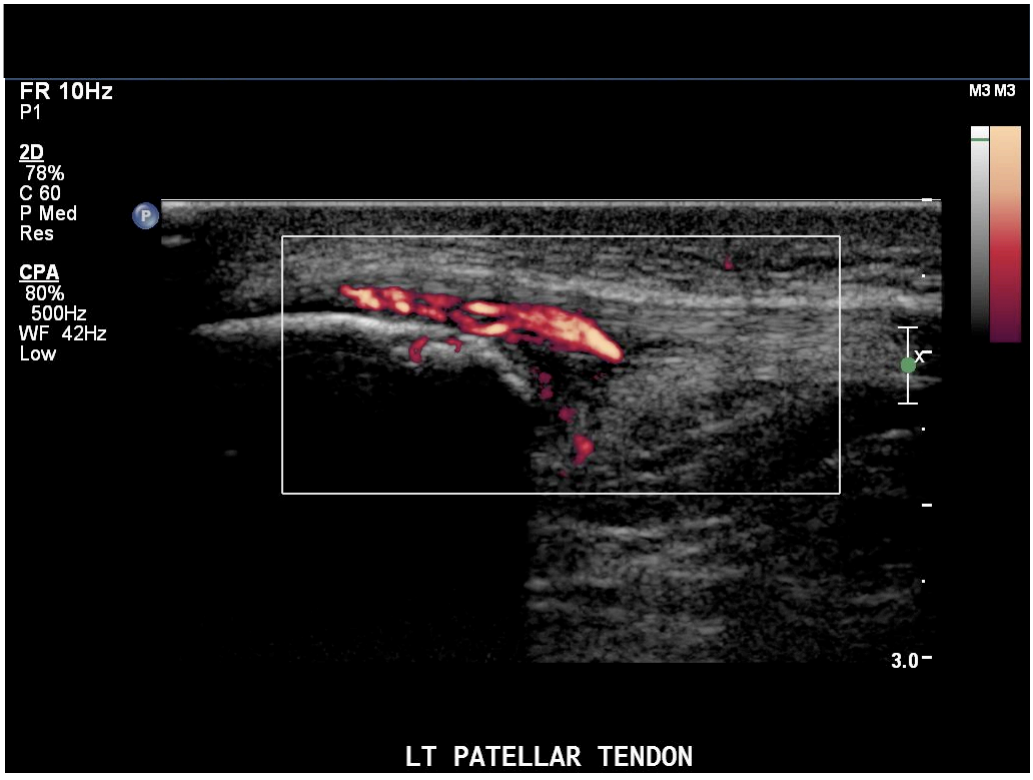

Figure 2. A 19-year old male with left anterior knee pain

Several studies have shown neovascularisation occurring within the tendon (Cook & Malliaras, 2004; Terslev & Qvistgaard, 2001; Weinberg et al., 1998). Vascularity in the tendon has been suggested to be a sign indicating an on-going inflammatory process; however, a study using microdialysis technique showed that there were no signs of a prostaglandin-mediated inflammation in the chronic stage of Jumper's knee (Alfredson, Forsgren, Thorsen, & Lorentzon, 2001).

The process of forming blood vessels (angiogenesis) is controlled by several stimulatory and inhibitory proteins. Inhibition of angiogenesis is required for the development and maintenance of hypovascular or avascular tissues. This might be affected either by production of an inhibitory factor or by a reduction of a stimulatory factor. A complex balance between pro and anti-angiogenesis factors are involved in neovascularisation (Pufe & Petersen, 2005).

Mechanoreceptors and nerve-related components such as glutamate N-methyl-D-aspartic acid (NMDA) receptors are present in association with blood vessels in tendinopathic tendons (Alfredson & Pietila, 1998). Some research has suggested that the vascular in-growth in tendinopathy is accompanied by nerval in-growth that facilitates pain transmission (Bjur & Alfredson, 2005). Two studies have suggested eccentric training in the achilles tendon might traction the area involving neovessels, and may be responsible for improved clinical results (Alfredson & Ohberg, 2006; Ohberg & Lorentzon, 2001).

2.4 Tendon pathology as a Continuum

Cook & Purdam's (2009) suggested model of tendon pathology looks at a continuum comprising three stages: Reactive Tendinopathy, Tendon Dysrepair (failed healing), and Degenerative Tendinopathy (Fig 3). There is continuity between the three stages and that the change of load is the primary stimulus that drives the tendon forward or back along the continuum.

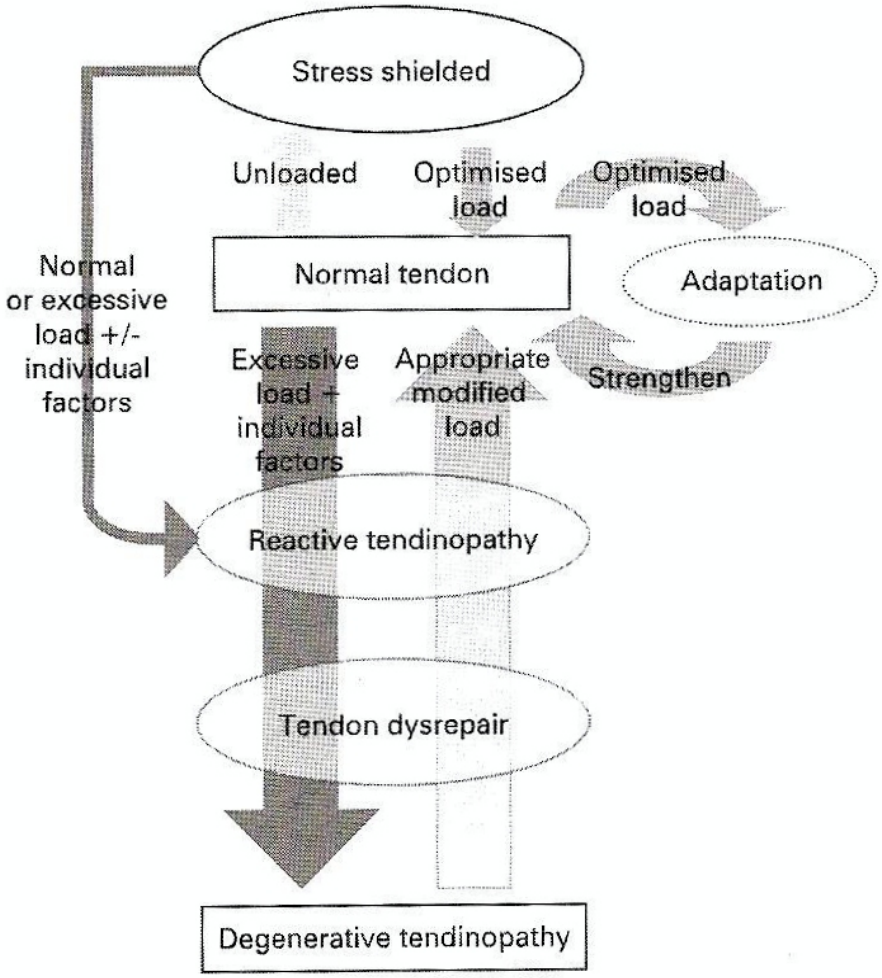

Figure 3. Pathology continuum

(Cook & Purdam, 2009 – Fig 1, Page 410)

This model embraces the transition from normal through to degenerative tendinopathy and highlights the potential for reversibility early in the continuum. Reversibility of pathology is unlikely in the degenerative stage (Cook & Purdam, 2009).

1. Reactive Tendinopathy

It is proposed that reactive tendinopathy is a non-inflammatory proliferative response in the cell and matrix that occurs with acute tensile or compressive overload. Reactive tendinopathy results from acute overload, usually a burst of unaccustomed physical activity. Thus, this reactive response is a short-term adaptation to overload that thickens the tendon, reduces stress and increases stiffness. The tendon has the potential to revert to normal if the overload is sufficiently reduced or if there is sufficient time between loading sessions. Ultrasound scan (USS) shows reflection from intact collagen fascicles, with diffuse hypoechogenicity occurring between intact collagen structures.

Reactive tendinopathy is seen clinically in an acutely overloaded tendon, and is more common in a younger person. For example, a young jumping athlete who dramatically increases the number of jumping/landing repetitions a week may develop patellar tendon swelling and pain.

Tendons chronically exposed to low levels of load (e.g. in the detrained athlete returning from illness or injury, or a sedentary person) may also be vulnerable to this stage of tendinopathy when exposed to moderate increase in load. In addition it may occur as a result of direct trauma to tendon, to which the achilles, patellar and elbow tendons are particularly exposed (Cook & Purdam, 2009).

2. Tendon Dysrepair

Tendon dysrepair describes the attempt at tendon healing, similar to reactive tendinopathy but with greater matrix breakdown. Imaging changes reflect increased matrix disorganisation, and swelling, with increasing evidence of collagen disorganisation. On USS there are small focal areas of hypoechogenicity. An increase in vascularity may be evident on colour or power Doppler.

This stage has been reported in chronically overloaded tendons in the young, but may appear across a spectrum of ages and loading environments. These tendons are thick with more localised changes in one area of the tendon. Some reversibility of the pathology is still possible with load management, and exercise, to stimulate matrix structure (Cook & Purdam, 2009).

3. Degenerative Tendinopathy

This stage is characterised by progression of both matrix and cell changes. Large areas of the matrix are disordered and filled with vessels, matrix breakdown products, and little collagen. There is little capacity for reversibility of pathological changes at this stage. These appear on USS as hypoechoic regions with few reflections from collagen fascicles. Numerous, and larger vessels are usually visible on Doppler USS. This stage is primarily seen in the older person, but is seen in a younger person or elite athlete with a chronically overloaded tendon (Cook & Purdam, 2009).

The inability of a tendon to recover once it reaches the degenerative stage is supported by studies that have examined tendons many years after injury or rupture. Although the tendons may improve their function, they do not appear to return to normal size or

morphology. Several studies have shown that large hypoechoic areas, suggesting degenerative change, do not change over time (Adriani, Mariani, & Maresca, 1995; Kharjalainen, Aronen, & Pihlajamaki, 1997; Sanchis-Alfonso, Subias-Lopez, & Monteagudo-Castro, 1999). Evidence of pathology however, does not always correlate with pain and/or symptoms.

2.5 Treatment Options for Patellar Tendinopathy

Ferretti et al (1985) suggested that previous lack of knowledge regarding pathophysiology and pain mechanisms associated with patellar tendinopathy, reflect the existence of many different treatment protocols. It has been agreed amongst authors that athletes with patellar tendinopathy receive exhaustive conservative treatment before considering surgical options (Peers & Lysens, 2005).

Andres & Murrell (2008) performed a systematic review of the literature to determine the best treatment options, and their effectiveness, for tendinopathy. Treatment options included non-steroidal anti-inflammatory drugs (NSAIDS), corticosteroid injections, exercise-based physical therapy, physical therapy modalities such as ultrasound and electrotherapy, extracorporeal shock wave therapy, sclerotherapy, topical glyceryltrinitrate patches, surgery, growth factors, and stem cell treatment. Other treatment programmes have seen use of heat, ice, massage, training modification, taping, platelet-rich plasma injections, dry needling and autologous blood injections (Cook & Khan, 2001; Scott et al., 2013).

There is a lack of scientific evidence in the literature for the majority of treatment programmes proposed and used for chronic tendon problems. The current trend in

therapeutic approach for patellar tendinopathy stresses the need for a more comprehensive focus on strengthening exercises to the musculo-tendinous complex.

As tendinopathy results from a failed healing response of overloaded tendons, it seems logical that strengthening should be the key element in a more pathology-based management of patellar tendinopathy (Peers & Lysens, 2005).

Cook & Purdam's (2009) model of tendinopathy placed different interventions in different stages of the continuum. They suggest a reduction in frequency and/or intensity of tendon load in the early tendon dysrepair (reactive) stage, compared with the late tendon dysrepair and degeneration stages where eccentric exercise, or another form of loading is implemented.

2.5.1 Surgical Management

Published surgical methods for the treatment of patellar tendinopathy include open tenotomy with excision of macroscopic necrotic area, arthroscopic patellar tenotomy, drilling/resection of the inferior pole of the patellar, resection of tibial attachment with realignment and quadriceps bone-tendon graft, longitudinal tenotomy, and percutaneous needling (Peers & Lysens, 2005). Success rates for surgical treatment of chronic proximal patellar tendinopathy has been reported as generally exceeding 80% in the literature (Peers & Lysens, 2005).

2.6 Review of Studies with Eccentric Tendon Loading

A review of studies using eccentric tendon loading was completed to gain better understanding of common outcome measures, the quality of previous studies, interventions including dosage and duration, control groups and the results achieved.

The use of eccentric training in the conservative treatment for patellar tendinopathy has shown some promising clinical results (Bahr et al., 2006; Frohm, Saartok, Halvorsen, & Renstrom, 2007; Jonsson & Alfredson, 2005; Young et al., 2005). The single leg squat performed on a decline board (EDS) has been described as a method to maximally load the knee extensors in an eccentric manner. It is used as an easy and effective rehabilitation exercise for patients with patellar tendinopathy (Jonsson & Alfredson, 2005; Purdam et al., 2004; Young et al., 2005).

2.6.1 Types of Studies

The studies had to be a randomised controlled trial, a clinical trial or a prospective study, and had to focus on clinical outcomes on human subjects.

2.6.2 Types of Participants

There was no age restriction on the participants.

2.6.3 Types of Intervention

All studies were required to have eccentric quadriceps loading (squats) as part of the intervention. The studies had to compare two or more interventions, one of which had to involve eccentric squats.

2.6.4 Outcome Measures

The outcome measures for these studies had to be related to changes in pain, function, patient satisfaction, or return to activity levels (eg: VISA-P, VAS, patient questionnaires).

2.6.5 Search Strategy for Patellar Tendinopathy and Eccentric Training.

The following electronic databases, subscribed to by Auckland University of Technology, were searched June 6, 2012 through the EBSCO host.

Biomechanical Reference Collection:Basic, Cinahl, Health Business Elite, Health Source:Consumer Edition, Medline, SPORTDiscus, Health Source:Nursing/ Academic Edition, Psycology and Behavioural Sciences Collection. The Physiotherapy Evidence Database (PEDro) was also searched. The key words used in isolation or combinations were: Patellar Tend*, Eccentric Training, Jumper* Knee, Eccentric Decline Squat.

The search was limited to studies written in English, and carried out on human participants. There was no limitation put on the date of publication, nor were there restrictions put on age, gender or activity levels of the study participants. The references of each paper were also reviewed, along with previous review papers, in order to identify other relevant articles.

2.6.6 Review and Analysis of Methodological Quality

The PEDro scale is used to assess methodological quality, and is based on the Delphi list (Verhagen et al., 1998). Its reliability has been reported as being ‘‘fair’’ to ‘‘good’’ in a

recent assessment (Maher, Sherrington, & Herbert, 2003), which concluded that the PEDro scale had sufficient reliability for its use in systematic reviews of physiotherapy randomised controlled trials (RCTs). The PEDro scale consists of 11 criteria, of which the first is not included in the final internal validity score. The answer to each criterion is a simple yes/no and the overall score of methodological quality is expressed as a mark out of 10. To achieve a 'yes', it must be explicitly clear upon reading the article that the criterion has been satisfied. A "yes" is worth 1 point, and a "no" is worth 0 points. Three assessors (MP, DR, WH) independently reviewed the included articles, and discrepancies in the scores were debated in order to determine the final quality scores (Stasinopoulos & Stasinopoulos, 2004) (Appendix I).

The PEDro Scale is an 11-item scale. The various items deal with differing aspects of RCT analysis including internal validity, external validity and statistics. In order to allow quantitative analysis of the overall methodological quality of each study, seven items which relate to internal validity were identified. These seven items include the following item numbers 2, 3, 5, 6, 7, 8, 9. The positive scores of each of these seven items is added together to calculate an Internal Validity Score (IVS) (Ellis, Hing, & Reid, 2007; Reid & Rivett, 2005). Based on the IVS of each paper, it is possible to make a qualitative assessment about the methodological quality (Ellis et al., 2007). The following levels of evidence were used to interpret the overall strength of the evidence (Ellis et al., 2007; Reid & Rivett, 2005).

Level 1: Strong evidence - when provided by generally consistent findings in multiple RCTs of high quality (IVS = 6–7).

Level 2: Moderate evidence - when provided by generally consistent findings in one RCT of high quality (i.e. IVS = 6–7) and one or more lower-quality RCTs (i.e. IVS<5).

Level 3: Limited evidence - when provided by generally consistent findings in one RCT of moderate quality (i.e. IVS = 4–5) and one or more low-quality RCTs (i.e. IVS<3).

Level 4: Insufficient evidence - when provided by generally consistent findings of one or more RCTs of limited quality (i.e. IVS<3), no RCTs available or conflicting results.

2.7 Results

2.7.1 Selection of Studies

The search resulted in 49 studies from the included databases. There were 9 duplicate references which were discarded. A check of reference lists resulted in the inclusion of 2 further studies. 32 articles did not meet our inclusion criteria, leaving 10 articles in this review. The search was repeated using the above methods on March 5, 2013. This resulted in one further article meeting the inclusion criteria, thus increasing the articles for review to 11. (Figure 4)

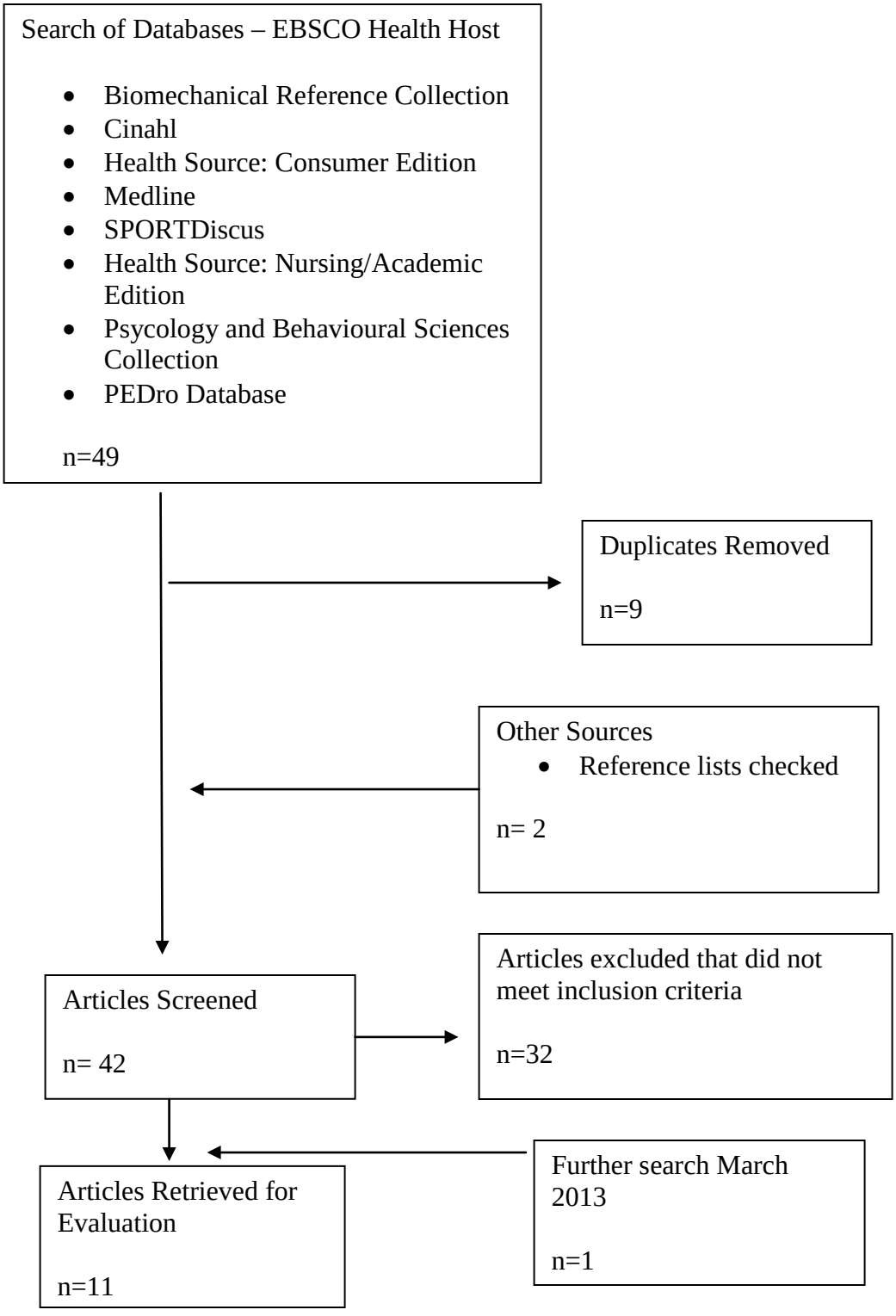

Figure 4. Flow diagram of selection process

2.7.2 Methodological Quality

The methodological quality of each paper, as assessed by the PEDro and IVS rating scales, are detailed in Table 1. The mean quality score for the studies reviewed was 6.3/10 (range 4-9).

One study was of high quality (IVS=6) (Steunebrink et al., 2013). Four of the studies were of moderate quality (IVS=4-5) (Bahr et al., 2006; Cannell, Taunton, Clement, Smith, & Khan, 2001; Kongsgaard et al., 2009; Visnes, Hoksrud, Cook, & Bahr, 2005), and six were of low quality (IVS <3) (Frohm et al., 2007; Jonsson & Alfredson, 2005; Purdam et al., 2004; Stasinopoulos, Manias, & Stasinopoulous, 2012; Stasinopoulos & Stasinopoulos, 2004; Young et al., 2005). This suggests therefore, that the literature reviewed provides moderate or Level 2 evidence across the studies with regard the effectiveness of eccentric intervention.

The PEDro scale results showed that in nine of the 11 studies (82%), subjects were randomly allocated to groups (Criteria 2) (Bahr et al., 2006; Cannell et al., 2001; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Stasinopoulos & Stasinopoulos, 2004; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005), and only 3 of the 11 studies (27%) showed concealed allocation (Criteria 3) (Bahr et al., 2006; Cannell et al., 2001; Steunebrink et al., 2013).

All but one study failed to meet criteria 5, relating to subject blinding (Steunebrink et al., 2013), and all studies failed to meet criteria 6 relating to therapist blinding. Five studies

(45%) met the criteria for assessor blinding (Cannell et al., 2001; Kongsgaard et al., 2009; Stasinopoulos et al., 2012; Steunebrink et al., 2013; Visnes et al., 2005).

One of the 11 studies (9%) did not meet requirements for Criteria 4, relating to baseline data of study completers being presented (Stasinopoulos & Stasinopoulos, 2004)

In each of Criteria 8-11, only 1 study (9%) in each respectively failed to meet the required criteria (Jonsson & Alfredson, 2005; Stasinopoulos & Stasinopoulos, 2004).

Table 1. PEDro Analysis

Authors	1	2	3	4	5	6	7	8	9	10	11	QS	IVS
Steunebrink, M., et al. (2013).	1	1	1	1	1	0	1	1	1	1	1	9	6
Cannell, L. J., et al. (2001).	1	1	1	1	0	0	1	1	1	1	1	8	5
Bahr, R., et al. (2005)	1	1	1	1	0	0	0	1	1	1	1	7	4
Kongsgaard, M., et al. (2009).	1	1	0	1	0	0	1	1	1	1	1	7	4
Visnes, H., et al. (2005).	1	1	0	1	0	0	1	1	1	1	1	7	4
Frohm, A., et al. (2007).	1	1	0	1	0	0	0	1	1	1	1	6	3
Stasinopoulos, D., et al. (2012).	1	0	0	1	0	0	1	1	1	1	1	6	3
Young, M. A., et al. (2005).	1	1	0	1	0	0	0	1	1	1	1	6	3
Purdam, C. R., et al. (2004).	1	0	0	1	0	0	0	1	1	1	1	5	2
Jonsson, P., et al. (2005).	1	1	0	1	0	0	0	0	0	1	1	4	1
Stasinopoulos, D., et al. (2004).	1	1	0	0	0	0	0	1	1	1	0	4	3

2.7.3 Study Characteristics

The characteristics of each study can be found in Table 2.

2.7.3.1 Participants

In total, 320 patellar tendons from 231 males and 66 females were included in the 11 studies. Seven studies gave subjects age as a range (15-53 years) (Bahr et al., 2006; Cannell et al., 2001; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Stasinopoulos et al., 2012; Stasinopoulos & Stasinopoulos, 2004; Visnes et al., 2005). Four studies presented age of subjects as an average, with an overall mean of 24.4 years (Frohm et al., 2007; Purdam et al., 2004; Steunebrink et al., 2013; Young et al., 2005).

2.7.3.2 Interventions

All 11 studies had eccentric squats as part of their design. All but one of the 11 studies used eccentric decline squats in their interventions (Cannell et al., 2001). Studies included interventions of varying lengths: a 12 week programme was undertaken in nine studies (Bahr et al., 2006; Cannell et al., 2001; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005), and two implemented studies of 4 weeks duration (Stasinopoulos et al., 2012; Stasinopoulos & Stasinopoulos, 2004). Seven of the studies prescribed 3 sets of 15 repetitions twice daily, 7 days a week (Bahr et al., 2006; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005). One study prescribed 3 sets of 15 repetitions once a day, 5 days a week (Stasinopoulos et al., 2012). The other two prescribed 3 sets of 15 repetitions twice a week, and three times a week, respectively (Frohm et al., 2007; Stasinopoulos & Stasinopoulos, 2004).

Final outcome measures were recorded at the conclusion of the 12 week programme in four of the studies (Frohm et al., 2007; Jonsson & Alfredson, 2005; Purdam et al., 2004; Steunebrink et al., 2013). Six studies used more than one follow up date ranging from 1 month (1 Study), 3 months (2), 6 months (4), 12 months (2), 15 months (1), and 32.6 months (1) (Bahr et al., 2006; Kongsgaard et al., 2009; Stasinopoulos et al., 2012; Stasinopoulos & Stasinopoulos, 2004; Visnes et al., 2005; Young et al., 2005).

2.7.3.3 Control / Comparison Groups

Comparison groups to the eccentric loading interventions varied across each study. Four studies compared EDS to eccentric squats on a flat surface (Frohm et al., 2007; Kongsgaard et al., 2006; Purdam et al., 2004; Young et al., 2005). Three studies compared EDS to concentric exercises (Cannell et al., 2001; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009). Other studies with one off comparisons included single leg vs double leg squats (Frohm et al., 2007), eccentric training vs surgery (Bahr et al., 2006), normal training (Visnes et al., 2005), heavy resistance training (Kongsgaard et al., 2009), pulsed ultrasound and friction massage (Stasinopoulos & Stasinopoulos, 2004), eccentric training plus stretching (Stasinopoulos et al., 2012), EDS with and without GTN therapy patches (Steunebrink et al., 2013) .

2.7.3.4 Outcome Measures

A variety of outcome measures were used in the reviewed studies. The most common primary outcomes were Victorian Institute of Sport Assessment (VISA-P) scores (8 studies) (Bahr et al., 2006; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et

al., 2009; Stasinopoulos et al., 2012; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005), and a pain Visual Analogue Scale (VAS) score (6 studies) (Cannell et al., 2001; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Young et al., 2005). One study used a simple patient evaluation form where subjects rate themselves better, worse, or no better (Stasinopoulos & Stasinopoulos, 2004).

The VISA-P is a specifically designed questionnaire used to quantify knee function in patellar tendinopathy, and has previously been shown to be valid and reliable (Vincentini & Khan, 1998). The VISA-P questionnaire consists of 8 questions that assess symptoms, simple functional tasks, and ability to undertake physical activity (Vincentini & Khan, 1998). The VISA-P scoring ranges from 0-100 points, where 100 points represents full knee function without pain (Appendix F).

Secondary outcomes included return to sport or activity, written questionnaires regarding satisfaction of outcome, subjective questioning of patient satisfaction and pain scores, tendon vascularisation, tendon thickness, muscle flexibility, and isokinetic muscle torque.

Table 2. Summary of Studies with Eccentric Decline Squat Regime

Author	Design	Participants	Interventions	Exercise Prescriptions	Outcome Measures	Results
Steunebrink, M., et al. (2013).	RCT	n=33 25 male,8 female Ages: 32.9 +/- 10yrs Ecc. Group n=33	Eccentric Decline Squats and placebo patches vs Eccentric Decline Squats and topical glyceryltrinitrate (GTN) patches Intervention -12 weeks	Eccentric single leg squats performed 3x15 repetitions twice a day, 7 days a week.	VISA-P Subjective patient evaluation and pain scores on a 0-10 scale	Improved VISA-P scores in both groups, but GTN patches did not improve clinical outcomes compared with placebo patches.
Cannell, L. J., et al. (2001).	RCT	n=19 13 male,6 female Ages:15-50 yrs Ecc. Group n=10	High eccentric load vs High Concentric load Intervention-12 weeks	1. Drop squats -three sets of 20drops once a day, five days a week. 2. Leg extension/curl -three sets of 10 lifts for each of the leg extension and leg curl exercises, once a day five days a week.	VAS Return to sport	Significant difference in pain reduction after intervention in both groups.
Bahr, R., et al. (2006).	RCT	n=35 (40 tendons) 31 male,4 female Ages:19-49 Ecc. Group n=20	Eccentric training vs Surgery Intervention -12 weeks	Eccentric single leg squats on a decline board. 3x15 twice a day, 7 days a week.	VISA-P	At 12 months follow up both groups had improved VISA-P scores, but there was no difference between the groups.
Kongsgaard, M.., et al. (2009).	RCT	n=39 (48 tendons) 39 males Ages: 18-53 yrs	Corticosteroid injections vs Eccentric Decline Squats vs Heavy Slow Resistance Training.	1.Two US guided injections 4 weeks apart 2. Eccentric single leg squats on a decline board. 3x15 twice a day, 7 days a	VISA-P VAS Tendon Vascularis-ation	VISA-P and VAS improved significantly and similarly in all groups at 12 week assessment. ECC training and HSR maintained clinical improvements

		2 Drop Outs Ecc. Group n=13	Intervention-12 weeks	week.(12 weeks) 3. Bilateral squat, leg press, hack squat at increasing at set reps/loads (RM) for 12 weeks.	Tendon swelling	at half-year follow up but deteriorated in Corticosteroid injection group at half year follow up.
Visnes, H., et al. (2005).	RCT	n=29 Ages:19-35 Ecc.Group n=13 1 Drop Out	Eccentric Decline Squats on board (n=13) vs control group which continued their normal training (n=16) Intervention-12 weeks	Eccentric single leg squats on a decline board. 3x15 twice a day, 7 days a week (12 weeks). Load was increased at 5kg increments.	VISA-P	There was no change in VISA-P score during the intervention period in the training or control group, nor was there any change during the follow up period at 6 weeks or 6 months.
Frohm, A., et al. (2007).	RCT	n=20 16 male,4 female Single Leg n=9 Ages: 28+/- 8 yrs Bilateral n=11 Ages:26+/- 8 yrs	Single Leg Decline Squats vs Bilateral Eccentric Squats Intervention -12 weeks	1. Eccentric single leg squats on a decline board. 3x15 twice a week. 2. Bilateral eccentric training using Brosman device twice a week	VISA-P VAS Dynamic Function. Muscle Flexibility.	VISA-P scores showed significant improvement in both groups, but no significant differences between the groups in terms of pain and function.
Stasinopoulos, D., et al. (2012).	Controlled Clinical Trial	n=43 31 male , 12 female Ages:18-30 yrs Ecc. Group n=43	Eccentric Decline Squats vs Eccentric Decline Squats and static stretching Intervention-4 weeks	1.Eccentric single leg squats performed 3x15 repetitions once/day, 5 days /week 2. Eccentric single leg squats performed 3x15 repetitions once/day, 5 days /week. 30 second static stretching of hamstrings and quadriceps before and after eccentric loading	VISA-P	VISA-P scores showed significant improvement in both groups There were significant differences in the VISA-P score between the groups at the end of treatment (+14; 10 to 18) and at the six-month follow-up (+19; 13 to 24); eccentric training and static stretching exercises produced the largest effect
Young, M. A., et al. (2005).	RCT	n=17 13 male,4	Eccentric loading vs Eccentric loading	1. Eccentric single leg squats on a decline board.	VISA-P VAS	Both groups had improved significantly from baseline at 12

		female Ages: 27.3 yrs (average) Ecc.Group n =17	Intervention-12 weeks	3x15 twice a day, 7 days a week (12 weeks). 2. Eccentric single leg squats on a step board. 3x15 twice a day, 7 days a week (12 weeks).		weeks and 12 months. Analysis of the likelihood of a 20 point improvement in VISA-P score at 12 months revealed a greater likelihood of clinical improvement in the decline group than the step group. VAS scores at 12 months did not differ between the groups.
Purdam, C. R., et al. (2004).	Non randomised	n=17 (22 tendons) 13 male, 4 female. Ages: 22 yrs (average) Ecc Dec Group n=8 Standard Squat n=9	Eccentric Squats vs Eccentric Decline Squats on a board. Intervention-12 weeks	Eccentric single leg squats performed 3x15 repetitions twice a day, 7 days a week (12 weeks).	VAS Return to activity	Good clinical results were obtained in the group who trained on the decline board. Significant results in reduced pain over the 12 week period. Standard squat group showed poor results.
Jonsson, P., et al. (2005).	RCT	n=15 (19 tendons) 13 male, 2 female Ages : 17-42 yrs (mean = 24.9) Ecc. Group n=10 3 Drop Outs	Eccentric Quadriceps training vs Concentric Quadriceps training Intervention-12 weeks	1. Eccentric single leg squats on a decline board. 3x15 twice a day, 7 days a week. 2. Concentric single leg squats on a decline board. 3x15 twice a day, 7 days a week.	VAS VISA-P	Significant decreases in pain in both the VAS and VISA-P for the eccentric group. No significant differences were found in the concentric group for the VAS and VISA-P.

Stasinopoulos, D., et al. (2004).	RCT	n=30 18 male,12 female Ages:21-33 yrs Ecc. Group n=10	Eccentric Decline Squats vs Pulsed Ultrasound vs Friction/Rest Intervention-4 weeks	Eccentric single leg squats performed 3x15 repetitions (3x/week)	Patient evaluation of pain (worse, no better, somewhat better, much better, no pain)	The eccentric programme was significantly better than the other two treatments at the end of treatment, and at the 2 and 3 month follow-ups.

2.8 Discussion

Results from this review indicate that the level of evidence is moderate (level 2). Consistent deficits in methodology included lack of blinding of subjects, therapists, and assessors (Refer to Table 1). When using exercise as an intervention in research, subject and therapist blinding will always be difficult.

All studies compared intervention groups to one or more control groups.

The review highlighted the apparent lack of specific research targeting rugby players.

2.8.1 Duration of programme and follow-up

Nine of the studies (Bahr et al., 2006; Cannell et al., 2001; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005) had an intervention period of 12 weeks, and the only reason given for this time frame appears to be based on clinical experience, though the literature states tendons take approximately 90-100 days to remodel (Vailas, Tipton, Laughlin, Tcheng, & Matthes, 1978). Two studies used 4 week intervention programmes and showed evidence of improved function and patient satisfaction in eccentric loading groups (Stasinopoulos et al., 2012; Stasinopoulos & Stasinopoulos, 2004). The follow up period in each study varied from the end of intervention to 36.5 months post intervention. There appear no standardised thoughts on the length of the follow up period.

Of the studies using 12 weeks intervention and VISA-P as an outcome, all but one (Visnes et al., 2005), showed significant improvement in VISA-P scores suggesting this length of intervention is appropriate, and marries up with tendon remodelling time.

2.8.2 Dosage of Exercise Regime

The eccentric squat training regime used by ten of the 11 studies in this review, was 3 sets of 15 reps. Seven studies followed this twice daily for 7 days a week (Bahr et al., 2006; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005). Other studies followed different, lesser volume regimes, with participants exercising between 2-5 times per week (Frohm et al., 2007; Stasinopoulos et al., 2012; Stasinopoulos & Stasinopoulos, 2004)

Whilst 12 weeks duration seems the optimum intervention length, it remains unclear from this review what the optimum dosage of exercise may be. All studies except one, (Visnes et al., 2005), showed improvement in outcome measures despite variation in dosage. All but one study (Visnes et al., 2005) using VISA-P as an outcome measure showed significant improvement, despite variation in dosage.

2.8.3 Measurements

2.8.3.1 Function

Eight studies examined function using the VISA-P scale (Bahr et al., 2006; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Stasinopoulos et al., 2012; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005). Six studies showed VISA-P score improvement with both intervention and control groups (Bahr et al., 2006; Frohm et al., 2007; Kongsgaard et al., 2009; Stasinopoulos et al., 2012; Steunebrink et al., 2013; Young et al., 2005). Three studies (Bahr et al., 2006; Frohm et al., 2007; Steunebrink et al., 2013) found no difference between the groups, whereas

Stasinopoulous et al. (2012) found there were differences between the groups at the end of treatment, and at six month follow up. Young et al. (2005) suggested there was a greater likelihood of clinical improvements in the intervention group based on the increase they saw in the VISA-P scores.

One study found no change in VISA-P score for either group during the intervention period, or at the follow up periods of 6 weeks and 6 months (Visnes et al., 2005). Jonsson & Alfredson (2005) found a significant difference in VISA-P score in the eccentric exercise group, compared with a concentric exercise group.

In summary, VISA-P scores for eccentric exercise groups improved significantly in 7 of the 8 studies using this outcome measure, and showed no improvement in 1 study. Figure 5 graphs the change in VISA-P scores in the 7 studies that used eccentric decline squats over a 12 week period. VISA-P scores improved in the control groups in 6 of the 8 studies, with 2 studies showing no improvement. Three of the studies showed the eccentric loading groups returned better VISA-P score results than the control groups. No study found control groups returned better VISA-P scores than the eccentric exercise groups. These results perhaps add some justification to our decision to trial an EDS programme as our intervention, and adds some weight to our hypothesis that we expect our EDS group to return better VISA-P scores than other interventions.

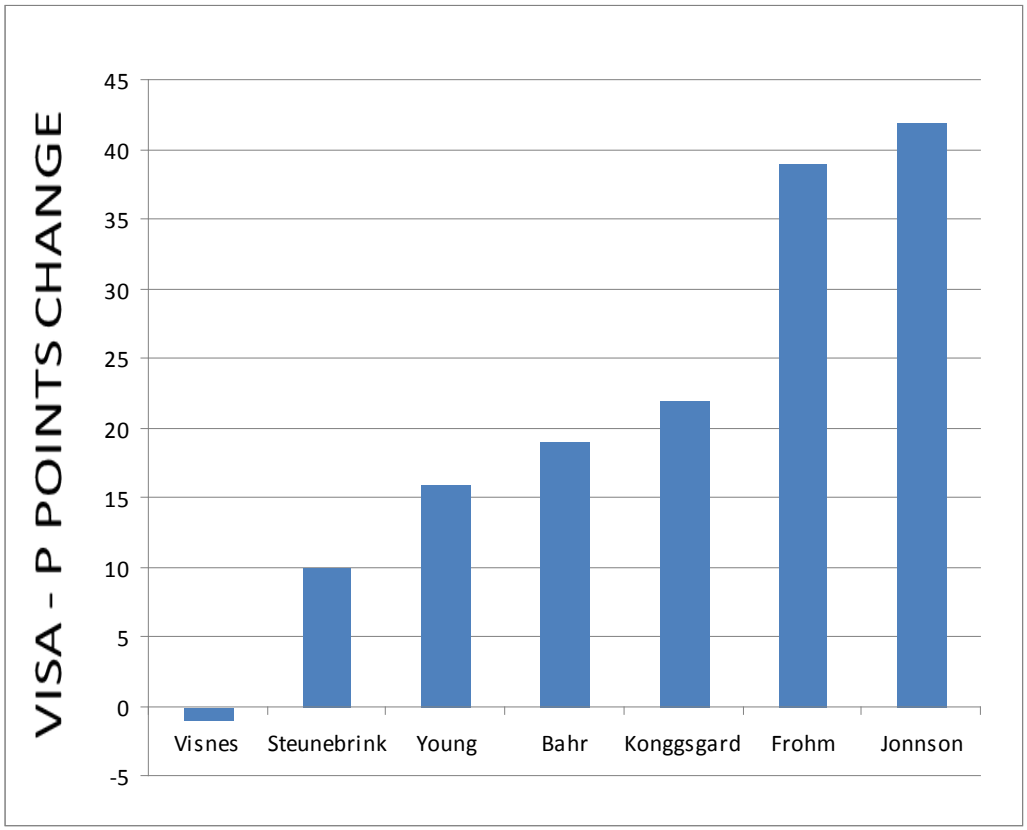

Figure 5. Change in VISA-P from baseline over 12 weeks

2.8.3.2 Pain

Six studies used pain VAS as an outcome measure (Cannell et al., 2001; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Purdam et al., 2004; Young et al., 2005). Two studies showed significant difference in pain reduction in both intervention and control groups (Cannell et al., 2001; Frohm et al., 2007). Similarly, Kongsgaard et al (2009) found significant improvement in VAS scores across both intervention and control groups, but some of those improvements were deteriorating in the corticosteroid injection group at the 6 months follow up. Two studies found better improvement with VAS scores in the eccentric decline squat group than the control

groups (Jonsson & Alfredson, 2005; Purdam et al., 2004). Young et al (2005) found that the VAS scores in their control group were better than the EDS group at 12 weeks. They reasoned this because the decline squat group were exercising into tendon pain whereas the control group was avoiding tendon pain.

In summary, VAS scores improved in 5 of the 6 studies with regard EDS groups, and improved in 5 of the 6 studies with regard control groups. Two studies showed better VAS scores with EDS compared with control groups, and one study found the opposite.

2.8.3.3 Patient Satisfaction/ Return to Sport

Three studies evaluated patient satisfaction with simple evaluation questionnaires. Stasinopoulous & Stasinopoulos (2004) used their own scale, and patients were asked to describe the status of their pain from the following alternatives: worse, no change, somewhat better, much better, no pain. They showed at the end of treatment, and at follow ups at one and three months, the eccentric exercise programme was statistically significantly better than the other two treatments. Steunebrink et al (2012) used a modified VAS scoring system along with subjectively getting patients to score their satisfaction using “poor, fair, good or excellent”. They concluded no significant difference in patient satisfaction between groups at a 24 week follow up. Bahr et al (2006) used a global evaluation score utilising a similar questionnaire to Steunebrink et al (2012), along with treatment satisfaction questions and functional tests of strength and jumping. Post hoc tests revealed greater improvement in global evaluation scores in the eccentric loading group at 3 months, while no differences were seen at 6 and 12 months follow up.

Bahr et al (2006) suggested that surgery demonstrated no advantage over eccentric strength training, and Stasinopoulous & Stasinopoulos (2004) concluded eccentric exercise appeared to be more effective than the other two interventions, pulsed ultrasound and friction.

Purdam et al (2004) simply recorded the patient's ability to return to previous (pre-injury) activity levels at the completion of the 12 week study. Nine out of 12 tendons in the EDS group returned to sport, whereas only one of ten tendons in the standard squat group returned to sport. Cannell et al (2001) reported nine of 10 subjects in their drop squat group returned to sporting activity by 12 weeks, but five of those subjects still had low level pain. Six of 9 in the leg extension/curl group returned to sporting activity by 12 weeks and four patients had low level pain. There was no significant difference between groups in numbers returning to sporting activity.

2.9 Conclusions

The literature reviewed provides moderate or Level 2 evidence across the studies, with regard to the methodological quality of studies that have examined eccentric loading.

It remains unclear what the optimum regime with regard dosage of eccentric exercises should be, or indeed the duration of the programme. It has been suggested that 3 sets of 15, performed twice daily, 7 days a week and over a 12 week period is based mostly on clinical experience (Woodley et al., 2007). To our knowledge, no studies have investigated the application of this treatment in rugby players.

3.0 Methods

3.1 Introduction

This next section will cover the study design, methods of data collection, tools used for the study and relevant outcome measures**.**

Participants were rugby players selected from professional, semi-professional and amateur teams within New Zealand, and the effectiveness of an EDS programme (see 3.3.2) for patellar tendinopathy was investigated. As discussed in 1.2, the hypothesis of the study is that an EDS programme of 12 weeks duration will give better VISA-P outcome results than alternative treatment regimes.

3.2 Study Design

An interventional study design was used for this study comparing the effectiveness of the EDS programme to alternative treatment regimes.

3.2.1 Participants

28 subjects (mean age 23.57 years, weight 106.25 kg, and height 185.61cm) participated in this study, and were recruited from rugby union teams within Auckland, New Zealand. Written and verbal explanations of their requirements were provided (Appendix B, C), and written consents obtained before commencement (Appendix D).

Subjects then had to meet inclusion and exclusion criteria as set in 3.2.2 and 3.2.3. The exact involvement and requirement of both intervention and control groups was fully explained. Subjects were allocated to one of two groups by way of a coin toss by the

primary researcher (MP). The intervention group followed the 12 week EDS protocol, whilst the control group received more “traditional” physiotherapy treatment. Eccentric Decline Squats were not included as a treatment for the control group.

The study was approved by the Auckland University of Technology Ethics Committee (AUTEC) on 13/01/12. The AUTEC Reference number 11/326 (Appendix H).

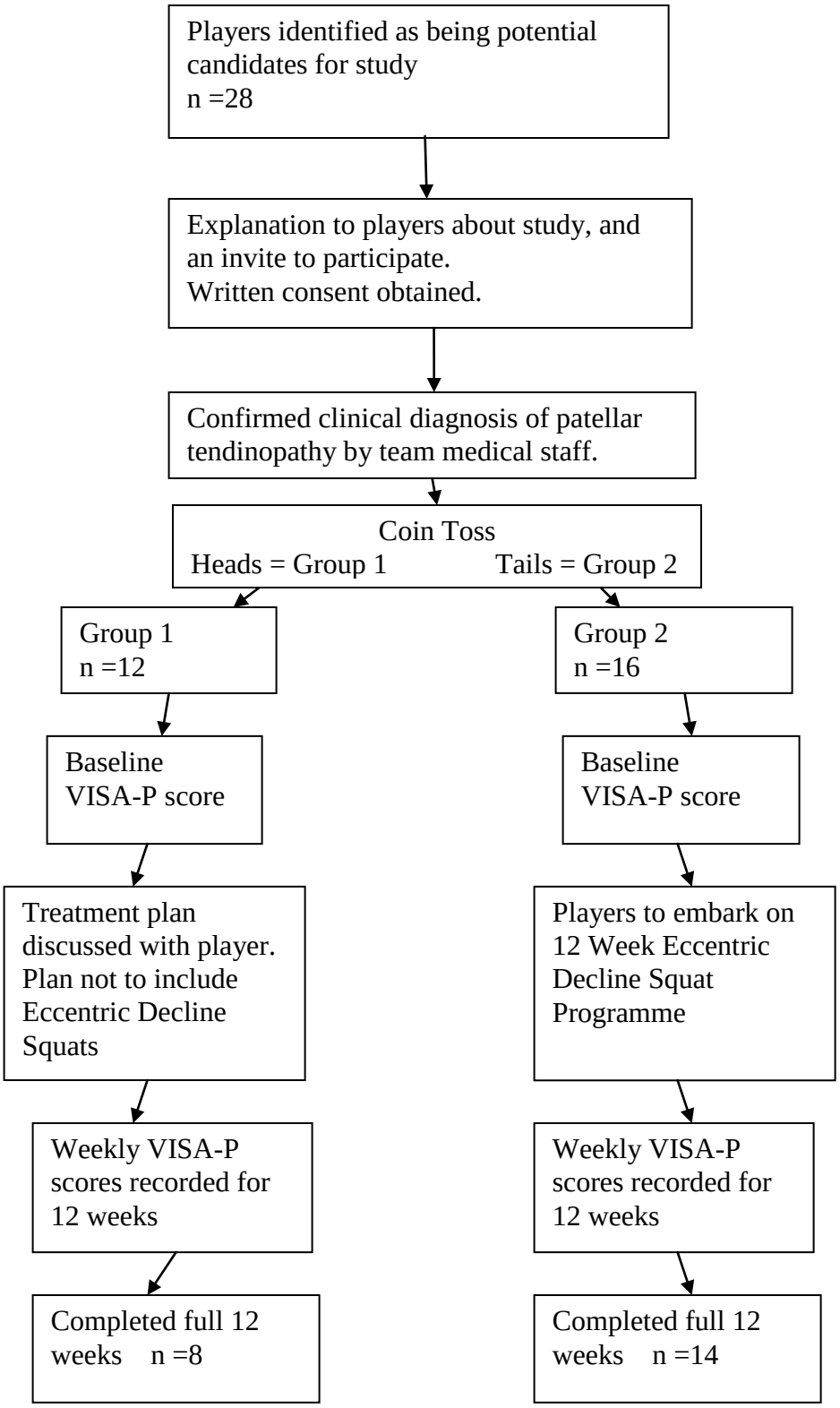

Figure 6. Method design flow diagram

3.2.2 Inclusion Criteria

All participants were assessed by team medical staff (Doctor and/or Physiotherapist)

The criteria for inclusion in this study were:

a. Proximal patellar tendon pain that was affecting sporting function (Lian, Engebretsen, & Bahr, 2005).
b. Localised patellar tendon pain on palpation. It has been suggested that palpation is a reliable test, but not necessarily a valid diagnostic test for this condition (Cook, Khan, Kiss, Purdam, & Griffiths, 2001).
c. Patellar tendon pain with jumping, squatting, running and/or stepping (Young et al., 2005).

There were no age restrictions for this study.

3.2.3 Exclusion Criteria

Participants were excluded if they currently had insertional patellar tendinopathy, any other knee conditions contributing to pain, and/or were receiving treatment for other problems around the knee region.

3.3 Equipment and Procedures

The following equipment and procedures were used; Decline boards, VISA-P outcome scoring sheets, Compliance sheets, Consent forms, Information sheets, Exercise description/protocol, symptomatic rugby players that meet criteria.

3.3.1 Control Group

The control group followed a traditional physiotherapy treatment plan as prescribed by their team physiotherapist. This may have included, but was not limited to; rest, electrotherapy, massage, friction, exercise, hot/cold treatment, strapping and/or altered training methods. This group did not have EDS as part of their management. Team physiotherapists each signed a Confidentiality Agreement (Appendix E). The team physiotherapist recorded weekly VISA-P outcome sheets (Appendix F). All the participants continued to train and play throughout the period they were being monitored.

3.3.2 Intervention Group - Eccentric Decline Squat

In line with a previous study on volleyball players (Young et al., 2005), the EDS were completed by participants twice a day (morning and night) for 12 weeks, utilising a 25 degree wooden decline board. Each loading session comprised of 3 sets of 15 repetitions. The eccentric (downward) phase of the squat was performed on the symptomatic leg, with knee flexion to approximately 60 degrees (Figure 7). The concentric (upward) phase was performed with the asymptomatic leg (Figure 8). Participants were instructed they could use their arms on a chair to assist the concentric phase if they wished (Appendix J). Participants were guided through the first 4 loading sessions with the team physiotherapist observing to ensure a consistent 60 degree knee angle was reached, along with correct technique.

Figure 7. Eccentric Phase

Figure 8. Concentric Phase

Participants were instructed to exercise up to moderate tendon pain, which was quantified as a 3-4/10 on a Visual Analogue Scale (VAS). They were also instructed to complete a compliance sheet (Appendix A) to monitor their exercise regime. The compliance sheet also allowed players to register whether or not they were taking medication during the study period. The only other modality allowed with the EDS group was icing, post exercise. Additionally, with participants continuing to train and play throughout the loading programme, they were given one day off the eccentric exercises each week, which was game day. The team physiotherapist recorded weekly VISA-P outcome sheets.

3.4 Outcome Measures

3.4.1 Victorian Institute of Sport Assessment (VISA-P) Questionnaire

All players undertook the questionnaire once a week and those results were recorded over a 12 week period. This was the primary outcome measure used, and the primary outcome point was 12 weeks. Where possible, the recordings were taken on the same day of each week – normally the first training day following a game (Appendix F). Compliance for the intervention group was assessed simply, with the players using a tick box "Compliance Sheet" following each exercise session (Appendix A). Over 12 weeks of intervention the maximum of 144 ticks would correspond to 100% compliance. Compliance sheets were analysed via descriptive statistics.

3.4.2 Ultrasound Scanning / RPE

Ultrasound scanning was used in this study, complimentary to the main outcome measure. Scans were done for interest reasons on a select number of participants. Not all subjects could be scanned due to financial constraints. The methodology, description and results of this sub-project can be found in Appendix L.

RPE (Records of Perceived Exertion) were collected to justify the inclusion of players from different levels of rugby. Again this was a sub-project of interest and the methodology, description and results can be found in Appendix M. The ultrasound and RPE data collected were not included in the main thesis due to incomplete data sets.

3.5 Statistical Analysis

The statistical analysis was undertaken using the SPSS statistical package (Version 20). For the primary outcome variable, the VISA-P scores, between groups comparison were undertaken using Two-way ANOVA. Bonferroni Post Hoc multiple comparisons were then used to identify where changes may have occurred. Demographic variables were analysed using independent *t* tests. The alpha level was set at 0.05.

4.0 Results

4.1 Introduction

This chapter is divided into two sections

The first section provides a description of the subjects that participated in the study. The second section presents VISA-P results for the participants.

4.2 Subjects

Data from twenty eight subjects were collected. All were males aged between 19 and 31 years (mean 23.57 years, SD 3.31). Descriptive characteristics of the subjects are presented in Table 3. Independent *t* tests indicated no significant difference was found between groups for the variables of age, height or weight ($p<0.05$). Not all subjects in the control group, or intervention group, completed the programme. Two of sixteen participants in the intervention group discontinued the programme at 6 weeks - one due to injury in a different body part, and the other happy with progress to that stage and preferring not to continue. Four of twelve participants in the control group dropped out - two at five weeks due to their rugby season ending, one at six weeks due to injury in a different body part, and the fourth left his club side before the end of the season and made no further contact with the club physiotherapist. Participant compliance to the EDS protocol in the intervention group was 81% of exercises completed (range 69-97%).

Table 4 shows the highest level of rugby each participant had attained at the time of entering the study.

Table 3. Participants Age, Height and Weight

Group	Number	Age in years (SD)	Height in cm (SD)	Weight in kg (SD)
Intervention	16	24.06 (3.78)	186 (5.52)	109.25 (11.32)
Control	12	22.91 (2.57)	185.08 (7.94)	102.25 (12.93)
Overall	28	23.57 (3.31)	185.61 (6.55)	106.25 (12.32)

Data are means and standard deviations.

Table 4. Highest Level of Rugby Played

International	Super 15	Provincial	Club	Total
4 players (14.3%)	10 players (35.7%)	6 players (21.4%)	8 players (28.6%)	28

4.3 Victorian Institute of Sport Assessment (VISA-P) Scores

The main outcome measure shows the intervention group improved VISA-P scores by 28.75 points over the 12 week programme, and the control group improved scores by 14.25 points over the same period of time.

In the intervention group it was noted that by 6 weeks in the programme there was a 24.5 point increase (86% of the final improvement), at 8 weeks a 27.4 point improvement (96%), and at 10 weeks a 28.1 point improvement (98.6%).

There were similar trends in the control group with a 13.1 point improvement seen at the 6 week mark (representing 93% of the final improvement). There was then a drop at 8

weeks with an improvement of 11 points (79%), and at 10 weeks a 13.3 point improvement (95%). The greatest VISA-P improvement seen between weeks was week 1 to 2 for both groups. The intervention group increased 7.25 points between week 1 and 2, and the control group increased 5.17 points between week 1 and 2. Appendix N displays tables of the average week by week VISA-P scores for both groups.

One way analysis of variance revealed the participants in the intervention group (EDS) improved their VISA-P scores significantly (*p=.000)* from 65.75 (SD 9.08) at baseline to 94.5 (SD 10.02), at the 12 week mark. Participants in the control group showed no significant improvement (*p=.900*) from baseline score of 66.75 (SD 15.49), to 81 (SD 18.33) at the 12 week mark (see Figure 9).

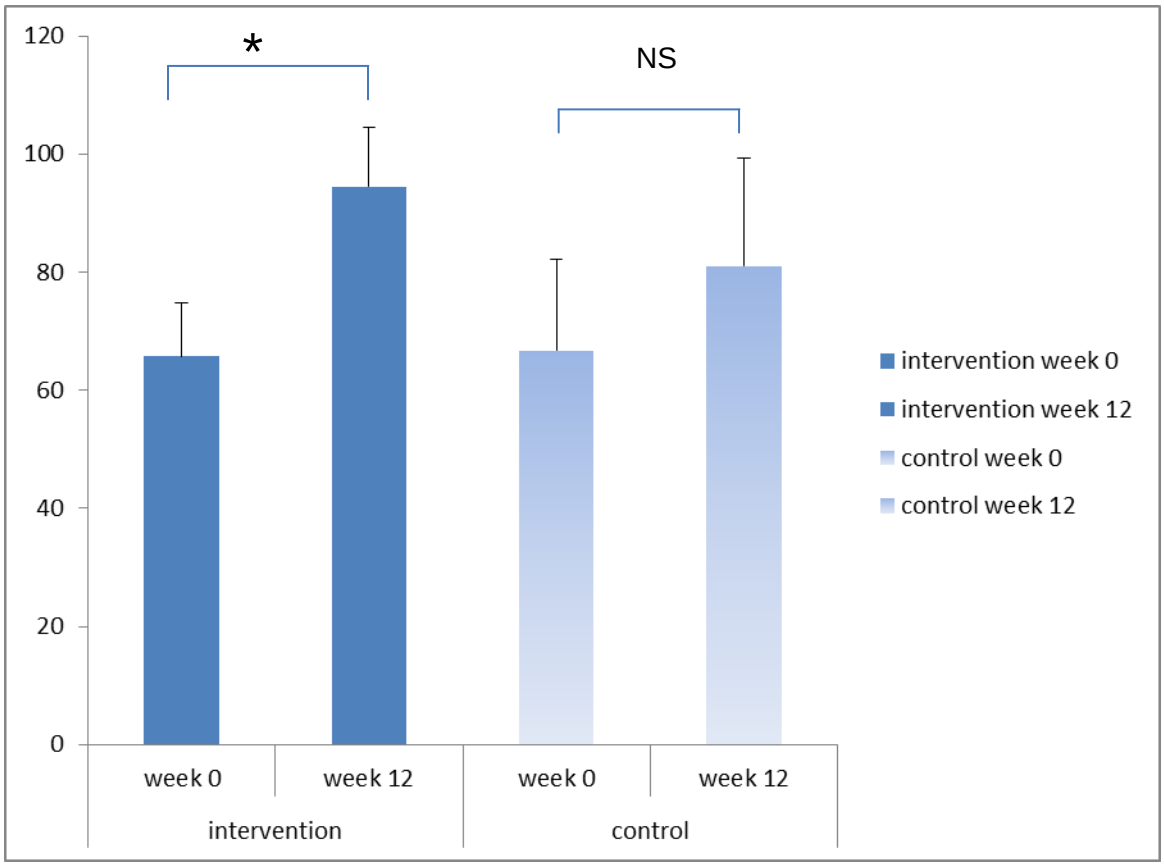

Figure 9. Overall VISA-P comparison of groups from baseline to week 12

Footnote: * significant ($p<0.05$); NS – non significant

The current study showed a significant effect ($p<0.05$) for time and group, and an interaction between time and group with regard VISA-P scores.

The mean baseline VISA-P scores, and weekly changes, are graphed in Figure 10.

Bonferroni Post Hoc Multiple Comparisons analysis for the intervention group has identified where the significant changes have occurred. There is no significant change between baseline VISA-P scores and weeks 1 and 2, but a significant change is seen comparing baseline to week 3 onwards ($p=.011$). There is a significant change comparing

week 1 to week 5 onwards (p=.009), and when comparing week 2 to week 11 (See Figure 10). Bonferroni Post Hoc Multiple Comparisons analysis for the Control group revealed there was no significant change for all comparisons.

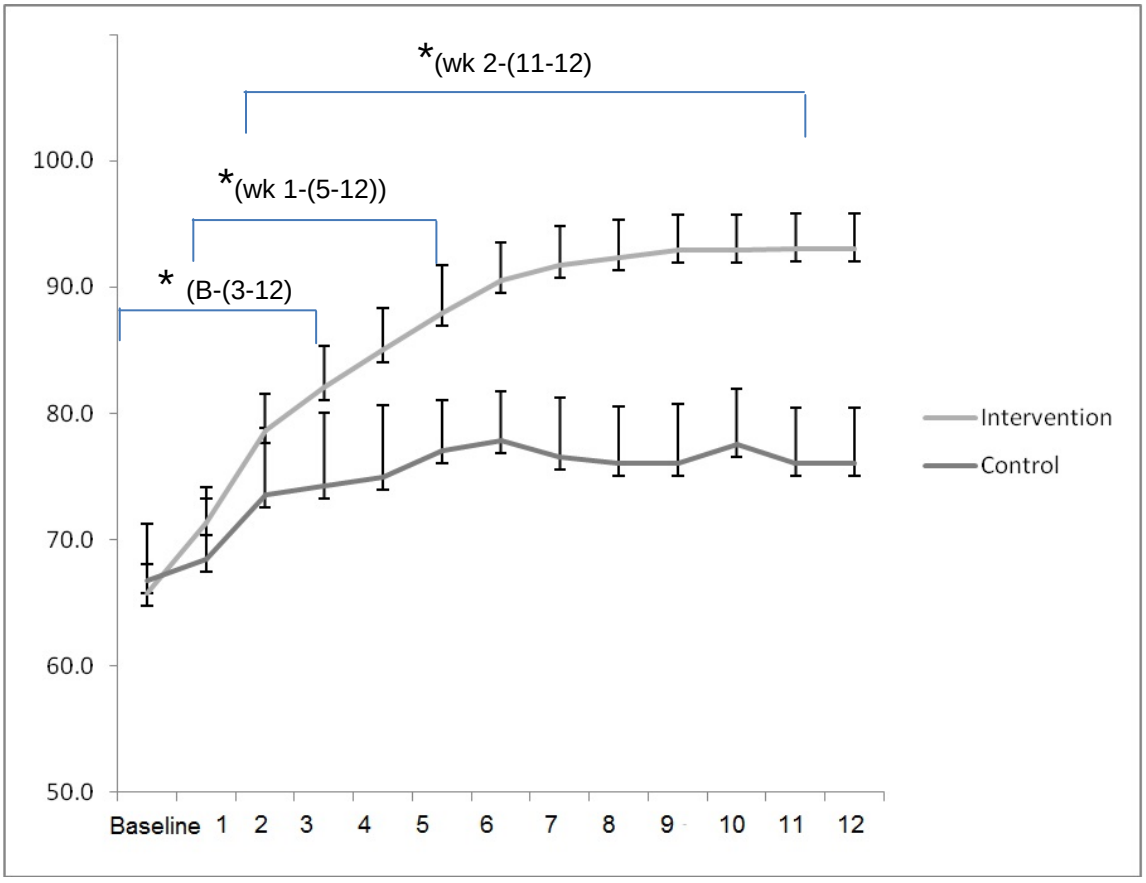

Figure 10. Mean VISA-P scores

Footnote: * significant ($p<0.05$): B- Baseline.

5.0 Discussion

5.1 VISA-P Scores

The results of this study indicate that the EDS intervention utilised in this study has a significant effect on pain and function associated with patellar tendinopathy. Interestingly, although not statistically significant, there was also an increase in the control group's VISA-P scores (14.25 points; 21 %). The mean VISA-P scores in the EDS intervention group improved by 28.75 points (43%) over the 12 week study period. In comparison, previous studies that have used EDS routines of 12 weeks duration reported improvements ranging from 0 to 102% (Bahr et al., 2006; Frohm et al., 2007; Jonsson & Alfredson, 2005; Kongsgaard et al., 2009; Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005). The results of this study showed the third highest levels of improved VISA-P scores published to date with a 28.75 point increase in the VISA-P score. Refer to 2.10.3.1, Figure 5.

On closer inspection of the aforementioned results Post Hoc analyses of this study's results revealed that the EDS group revealed no significant change between baseline VISA-P scores and weeks 1 and 2, but a significant change compared to week 3 ($p=.011$) and onwards. A significant improvement from week 1 to week 5 ($p=.009$) also occurred. The finding of the main improvements occurring from the baseline through to week 5 is consistent with Stasinopoulos et al (2012) who found a significant improvement in VISA-P scores over a 4 week EDS programme. Perhaps this may indicate that programmes of lesser duration may be as effective as a 12 week EDS programme.

Young et al (2005) used a more contemporary analysis to determine the likelihood of obtaining a clinically worthwhile outcome. These authors set the smallest clinically important change in VISA-P scores at 20 points (a 20 point improvement was considered to reflect a significant change in functional capacity). The clinical significance was finally calculated by considering the probabilities that the effect was clinically positive (greater than 20 points), trivial (20 to -10 points), or negative (less than -10 points) for each participant. The current study would therefore, using Young's analysis, suggest a clinically significant change in functional outcome for the intervention group.

With respect to inclusion criteria, the literature reports a wide variance with regard the length of time subjects had been symptomatic. Five of the seven studies set a minimum period of 3 months for inclusion, whereas some studies did not stipulate any time duration for symptoms. At one end of the scale Steunebrink et al (2013) reported symptoms between 3-24 months, and Jonsson & Alfredson (2005) had a mean symptom period of 17 months, whereas other studies did not state a minimum period. This variation may have some bearing on the differences seen in VISA-P scores. It must be stated that in our study we did not stipulate a minimum period of symptoms, and all players were recruited irrespective of time frames.

One other observation with respect to inclusion criteria was that three of the previous studies (Steunebrink et al., 2013; Visnes et al., 2005; Young et al., 2005) required a baseline VISA-P score of less than 80 points, which was not part of the inclusion criteria in this study.

5.2 Compliance

Within our study compliance was assessed in the EDS group using a simple tick chart. An overall compliance was measured at 81%, which is similar to other studies that looked at eccentric squats over a 12 week period. These include Visnes et al (2005) reporting 59%, Bahr et al (2006) 66%, Steunebrink et al (2013) >70%, Young et al (2005) 72% and Kongsgaard et al (2009) 89%. With respect to our study we feel it would be difficult to say whether a greater compliance might improve the VISA-P scores.

5.3 Loading

There is variation in the literature as to whether an athlete should cease normal sporting activity whilst undertaking eccentric strength programmes. Visnes et al (2005) concluded there was no effect on knee function (VISA-P scores) from a 12 week programme with eccentric training among a group of volleyball players with patellar tendinopathy when continuing to train and compete during the treatment period. In contrast Silbernagel et al (2007) demonstrated no negative effects from allowing patients to continue achilles tendon loading activity (such as running and jumping) whilst completing an eccentric load strength programme. The current study allowed players to continue training, and playing rugby at their pre-intervention levels. Whilst 6 of 28 participants dropped out of the study, none of their reasons were attributed to pain or disability associated to their knee. Further supporting the theory of continued activity, Young et al (2005) indicated that a decline squat protocol offered greater clinical gains during a rehabilitation programme for patellar tendinopathy in a group of volleyball players who continued to

train and play with pain. Their results showed significant improvement in VISA-P scores over a 12 week period. Kongsgaard et al (2009) allowed sporting activity to continue provided discomfort did not exceed 30 on a 100 point VAS scale.

With respect to limiting sporting activity whilst undertaking eccentric loading programmes, other studies also revealed significant improvements in VISA-P scores (Jonsson & Alfredson, 2005; Purdam et al., 2004; Stasinopoulos et al., 2012). Purdam et al (2004) used VAS and return to activity measures, and reported good clinical results with significant reduction of pain.

To date previous studies appear to be unclear whether cessation, or continuation of sporting activity during an EDS programme, has a bearing on VISA-P outcomes or indeed on pain, function or disability. Currently there appear to be no studies comparing eccentric programmes where one group continues sporting activity, and a control group stops sporting activity.

5.4 Limitations

This study recruited all participants who met the clinical inclusion criteria.

One limitation was that the minimum length of time participants had symptoms was not stipulated. However, much of the literature suggests that EDS effectiveness is not necessarily related to chronicity, and that whilst chronicity may be reflected in tendon changes seen on ultrasound imaging, it may not be reflected in terms of pain and function.

The method of group allocation in this study could be seen as an element of potential bias. This was decided upon as the easiest and most cost effective way to allocate the athletes. Further studies would be encouraged to have more robust ways of allocating.

A decision was made to recruit athletes in this study despite their competition level. Supporting this was that there was no significant difference between the groups (amateur, semi-professional and professional) for the variables of age, height or weight, and on field RPE values (Appendix M).

With respect to individual athletes attitude and commitment to; rehabilitation, injury prevention regimes, on field training, gym training, nutrition and recovery protocols, the authors acknowledge these variables can influence outcomes, but measuring these was not in the scope of this research.

5.5 Future research

Further studies with larger numbers specific to the rugby population and patellar tendinopathy are required. Our research is a start to understanding what may be best practice specific to rugby union players with patellar tendinopathy. Future research using VISA-P outcome measure will continue to allow comparisons with other treatment options. Mandatory baseline and follow up ultrasound imaging in future studies would allow further clarification of the relationship between imaging results and objective clinical outcome measures (i.e., VISA-P).

Future studies will also need to determine optimum length of intervention, along with the dosage and frequency of the EDS protocol.

A future recommendation would be for more studies of varied lengths to further assess where the greatest improvements are seen with eccentric decline squat exercises. From the literature, and this study, it is hypothesised that shorter length regimes followed by more “maintenance phase” weeks may achieve similar results as a 12 week programme. Further studies could also assess the dosage of intervention with respect to frequency, repetitions and length of programme. Another potential research question could be whether instigating a ‘preventative programme’ of EDS would benefit a rugby population.

6.0 Conclusion

Patellar tendinopathy is a highly prevalent sports injury, which can have a cyclical pattern of symptoms and remissions, and is difficult to resolve.

This thesis is one of the first research studies looking at Eccentric Decline Squat (EDS) in a rugby population that continued to train and play. Using VISA-P scoring, the results in this study suggested EDS offered greater effectiveness than other treatment options over a 12 week period.

The results of this study support, and recommend, the use of EDS in a rugby population with this injury. Further studies involving greater numbers, and comparing EDS to other treatment regimes, may add weight to these findings.

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Appendix A

Player Compliance - (3 x 15 Single Leg Eccentric Strengthening- Twice Daily)

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Notes
Week 1								
Meds								
Week 2								
Meds								
Week 3								
Meds								
Week 4								
Meds								
Week 5								

Appendix B

Participant Information Sheet

Date Information Sheet Produced: 20 November 2011

The Effect of Eccentric Decline Squats In The Management of Patellar Tendinopathy In Elite Rugby Players

Investigators: Mark Plummer, Dr Wayne Hing, Duncan Reid, Dr Stephen Kara

An Invitation

Hi, my name is Mark Plummer, Head Physiotherapist for the Blues Rugby Franchise. My supervisors Professor Wayne Hing, Duncan Reid and I would like to invite you to take part in an exercise programme we hope will assist elite rugby players with patellar tendinopathy (Jumper's Knee).
Please read the following and decide whether or not you would like to be involved. You do not have to be involved, and you can stop your involvement in the study at any time without adverse consequences.
It is my intention to use some of the data gained to complete a thesis for a Master of Health Science at AUT University.

What is the purpose of this research?

The study is looking at elite rugby players with anterior knee pain below the knee cap. This is commonly known as "Jumper's Knee ".

How was I identified, and why am I being invited to participate in this research?

You are an elite (professional or semi-professional) rugby player with patellar tendinopathy. Your medical team will do an assessment to ensure you meet the criteria. You can participate if you have had no other knee conditions.

What will happen in this research?

An ultrasound image of your knee will be taken early on in this study to assist with the diagnosis. This visit will take approximately 15 minutes. The scan will involve you lying down and then an experienced sonographer will take pictures of your knee tendon.
Exercise Training: You will be asked to perform a single knee squat twice daily, three sets with 15 repetitions on a 25 degree decline board.
You will be guided through the first 4 loading sessions to ensure a consistent knee angle and correct technique is performed.

What are the discomforts and risks?

You may feel some discomfort in the patella tendon while doing the exercise programme. This will be mild and will only be felt while performing the exercise itself. This mild discomfort is not harmful and expected. You will have the choice to stop the exercise programme at any stage.
There are no risks associated with an ultrasound scan. This is non-invasive.

How will these discomforts and risks be alleviated?

It is important to know that you may stop the exercise programme at any stage.
Testing will be performed with trained medical professionals (team Doctor or Physiotherapist) at hand.
A telephone will be on hand to call for immediate assistance if required.

What are the benefits?

This exercise programme may assist in reducing pain in your patellar tendon, and/or improve your functional ability. Previous studies on Achilles tendon pain have shown that exercise treatment reduced pain and improved functional abilities. Studies on patellar tendinopathy have shown similar results with eccentric decline squats.
It is our proposal that with fully compliant elite rugby players we can effect similar improvements with a 12 week decline squat programme.
Mark Plummer intends to use the data to assist gaining his Master of Health Science.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

- Your participation is entirely voluntary.

- For players within the Blues Rugby Franchise, an independent researcher will contact you and consult with you, explaining the processes, including what the programme involves, your rights, any concerns you may have and consent agreement. This independent person will not be involved in the study in any other way, and will have no relationship with players in the team environment. One of the team trainers will then take you through the exercise regime and collect weekly scores from you.

- You are free to withdraw from the project at any time, without giving any reason

- If you withdraw from the study before completion the data that has been collected so far will be destroyed if you do not want us to use it.

- Your identity will be kept strictly confidential, and no material which could personally identify you will be used in any reports of the study

- This study is non-invasive. The use of ultrasound is to view your tendon structure only.

- You may choose not to partake in this study if you are uncomfortable with the outcomes that may occur with this scan

- If you need an interpreter one can be provided.

- You are encouraged to consult with whanau/family, hapu or iwi regarding participation in this project.

What are the costs of participating in this research?

There will be no financial costs involved for any participant.
In terms of time:

- Ultrasound Scan – approx 15 minutes

- Exercise – approx 15 minutes / day 6 days a week.

Funding

It is the intention of the researchers to ask for a contribution towards course fees to the below organisations.

New Zealand Society of Physiotherapists
New Zealand Manipulative Physiotherapists Association
Blues Super 15 Rugby Franchise
New Zealand Rugby Union

What opportunity do I have to consider this invitation?

- You may take the time you need and decide whether or not you would like to be involved.

- You can stop your involvement in the study at any time.

How do I agree to participate in this research?

If you agree to participate in the study you will need to fill out the consent form provided.

Will I receive feedback on the results of this research?

Yes, individual feedback will be provided to you. The group results will be used in a written report as part of Mr Plummer's degree qualification (copy of report available on request) and the study's findings may eventually be published in a scientific journal.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor,

Professor Wayne Hing
Bond University
Faculty of Health Sciences and Medicine
Gold Coast, Queensland 4229, Australia
Health & Rehabilitation Research Institute
School of Rehabilitation & Occupation Studies
AUT University, Auckland New Zealand
61 4 22253651 (mob)
whing@bond.edu.au

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Dr Rosemary Godbold.
rosemary.godbold@aut.ac.nz , 921 9999 ext 6902.

Whom do I contact for further information about this research?

Researcher Contact Details:

Mark Plummer
Blues Rugby Physiotherapist
mark.plummer@aucklandrugby.co.nz
Ph 0275622000

Dr Stephen Kara
Blues Rugby Doctor
stephen.kara@aucklandrugby.co.nz
Ph 0274676681

Project Supervisor Contact Details:

Professor Wayne Hing
Bond University, Australia
AUT University, New Zealand
61 4 22253651 (mob)
whing@bond.edu.au

Approved by the Auckland University of Technology Ethics Committee on 13/01/12.
AUTEC Reference number 11/326

Appendix C

Participant Information Sheet

Date Information Sheet Produced: 20 November 2011

The Efficacy of Eccentric Decline Squats In The Management of Patellar Tendinopathy In Rugby Players

Investigators: Mark Plummer, Dr Wayne Hing, Duncan Reid, Dr Stephen Kara

An Invitation

Hi, my name is Mark Plummer, Head Physiotherapist for the Blues Rugby Franchise. My supervisors Professor Wayne Hing, Duncan Reid and I would like to invite you to take part in a study comparing different treatment approaches for rugby players with Patellar Tendinopathy (Jumper's Knee).

Please read the following and decide whether or not you would like to be involved. You do not have to be involved, and you can stop your involvement in the study at any time without adverse consequences.

It is my intention to use some of the data gained to complete a thesis for a Master of Health Science at AUT University.

What is the purpose of this research?

The study is looking at rugby players with anterior knee pain below the knee cap. This is commonly known as "Jumper's Knee ".

How was I identified and why am I being invited to participate in this research?

You are a rugby player with patellar tendinopathy. Your medical team will do an assessment to ensure you meet the criteria. You can participate if you have had no other knee conditions.

What will happen in this research?

An ultrasound image of your knee will be taken early on in this study to assist with the diagnosis. This visit will take approximately 15 minutes. The scan will involve you lying down and then an experienced sonographer will take pictures of your knee tendon.
Your team physiotherapist will discuss with you your treatment plans. You will be offered usual care by your physiotherapist aimed at treating the condition with common physiotherapy techniques. These may include electrotherapy, massage, friction, exercises, hot/cold treatment, strapping and/or altered training methods.
You will also be required to answer a questionnaire once a week for 12 weeks. This involves 8 questions which allow us to gauge your progress, and should take no longer than 5 minutes each time.

What are the discomforts and risks?

You may feel some discomfort in the patella tendon with some treatment techniques. This mild discomfort is not harmful and expected.
There are no risks associated with an ultrasound scan. This is non-invasive.

How will these discomforts and risks be alleviated?

It is important to know that you may stop treatment at any stage.
Treatments will be performed by trained Physiotherapists.
A telephone will be on hand to call for immediate assistance if required.

What are the benefits?

The treatment received may assist in reducing pain in your patellar tendon, and/or improve your functional ability.
Mark Plummer intends to use the data to assist gaining his Master of Health Science.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

- Your participation is entirely voluntary.
- You are free to withdraw from the project at any time, without giving any reason
- If you withdraw from the study before completion the data that has been collected so far will be destroyed if you do not want us to use it.

- Your identity will be kept strictly confidential, and no material which could personally identify you will be used in any reports of the study

- This study is non-invasive. The use of ultrasound is to view your tendon structure only.

- You may choose not to partake in this study if you are uncomfortable with the outcomes that may occur with this scan

- If you need an interpreter one can be provided.

You are encouraged to consult with whanau/family, hapu or iwi regarding participation in this project.

What are the costs of participating in this research?

There will be no financial costs involved for any participant.
In terms of time:

- Ultrasound Scan – approx 15 minutes

- Treatment Times – to be agreed upon between you and your physiotherapist.

Funding

It is the intention of the researchers to ask for a contribution towards course fees to the below organisations.

New Zealand Society of Physiotherapists
New Zealand Manipulative Physiotherapists Association
Blues Super 15 Rugby Franchise
New Zealand Rugby Union

What opportunity do I have to consider this invitation?

- You may take the time you need and decide whether or not you would like to be involved.

- You can stop your involvement in the study at any time.

How do I agree to participate in this research?

If you agree to participate in the study you will need to fill out the consent form provided.

Will I receive feedback on the results of this research?

Yes, individual feedback will be provided to you. The group results will be used in a written report as part of Mark Plummer's degree qualification (copy of report available on request) and the study's findings may eventually be published in a scientific journal.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor,

Professor Wayne Hing
Bond University
Faculty of Health Sciences and Medicine
Gold Coast, Queensland 4229, Australia
Health & Rehabilitation Research Institute
School of Rehabilitation & Occupation Studies
AUT University, Auckland New Zealand
61 4 22253651 (mob)
whing@bond.edu.au

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Dr Rosemary Godbold.
rosemary.godbold@aut.ac.nz, 921 9999 ext 6902.

Whom do I contact for further information about this research?

Researcher Contact Details:

Mark Plummer
Blues Rugby Physiotherapist
mark.plummer@aucklandrugby.co.nz
Ph 0275622000

Dr Stephen Kara
Blues Rugby Doctor
stephen.kara@aucklandrugby.co.nz
Ph 0274676681

Project Supervisor Contact Details:

Professor Wayne Hing
Bond University, Australia
AUT University, New Zealand
61 4 22253651 (mob)
whing@bond.edu.au

Approved by the Auckland University of Technology Ethics Committee on 13/01/12.
AUTEC Reference number 11/326

Appendix D

Consent Form

The Effect of Eccentric Decline Squats In The Management of Patellar Tendinopathy In Elite Rugby Players

Project Supervisors: Professor Wayne Hing, Duncan Reid

Researchers: Mark Plummer, Dr Stephen Kara

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 20 November, 2011.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the interviews
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Participant's signature:

.....……

Participant's name:

.....……

Participant's Contact Details (if appropriate):

……..

……..

……..

……..
Date:
Approved by the Auckland University of Technology Ethics Committee on 13/01/12. AUTEC Reference number 11/326.
Note: The Participant should retain a copy of this form.

Appendix E

Confidentiality Agreement

Project title:

The Effect of Eccentric Decline Squats In The Management of Patellar Tendinopathy In Elite Rugby Players

Project Supervisor: ***Professor Wayne Hing, Dr Duncan Reid.***

Researcher: ***Mark Plummer***

- ○ I understand that all the material I will be asked to record is confidential.
- ○ I understand that the contents of the Consent Forms and relevant information can only be discussed with the researchers.
- ○ I will not keep any copies of the information nor allow third parties access to them.

Intermediary's signature:

.....……

Intermediary's name:

.....……

……

Intermediary's Contact Details (if appropriate):

……..

……..

……..

……..

Date:

Project Supervisor's Contact Details

Professor Wayne Hing
Bond University, Faculty of Health Sciences and Medicine
Gold Coast, Queensland 4229, Australia
Health & Rehabilitation Research Institute School of Rehabilitation & Occupation Studies AUT University Auckland New Zealand

61 4 22253651 (mob)

Approved by the Auckland University of Technology Ethics Committee on 13/01/12. AUTEC Reference number 11/326.
Note: The Intermediary should retain a copy of this form.

Appendix F

Patellar Tendinopathy Recording Sheet	
	VISA-P Score
Baseline	
Week 1	
Week 2	
Week 3	
Week 4	
Week 5	
Week 6	
Week 7	
Week 8	
Week 9	
Week 10	
Week 11	
Week 12	

Excel Spreadsheet - Recording Sheet For VISA-P Scores

Appendix H

M E M O R A N D U M

Auckland University of Technology Ethics Committee (AUTEC)

To:	WayneHing
From:	**Dr Rosemary Godbold** Executive Secretary, AUTEC
Date:	13 January 2012
Subject:	Ethics Application Number 11/326 **Eccentric decline squat in management of patellar tendinopathy in elite rugby players.**

Dear Wayne

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 12 December 2011 and I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 13 February 2012.

Your ethics application is approved for a period of three years until 13 January 2015.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 13 January 2015;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. This report is to be submitted either when the approval expires on 13 January 2015 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have

any further enquiries regarding this matter, you are welcome to contact me by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 6902.
On behalf of AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.
Yours sincerely

Dr Rosemary Godbold
Executive Secretary
Auckland University of Technology Ethics Committee
Cc: Mark Richard Plummer mark.plummer@aucklandrugby.co.nz

Appendix I

PEDro scale

1. Eligibility criteria were specified no _ yes _ where:
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received) no _ yes _ where:
3. Allocation was concealed no _ yes _ where:
4. The groups were similar at baseline regarding the most important prognostic indicators no _ yes _ where:
5. There was blinding of all subjects no _ yes _ where:
6. There was blinding of all therapists who administered the therapy no _ yes _ where:
7. There was blinding of all assessors who measured at least one key outcome no _ yes _ where:
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups no _ yes _ where:
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat" no _ yes _ where:
10. The results of between-group statistical comparisons are reported for at least one key outcome no _ yes _ where:
11. The study provides both point measures and measures of variability for at least one key outcome no _ yes _ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (Verhagen et al, 1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41).

The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.
The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the “validity” of a study’s conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

(Verhagen et al., 1998)

Appendix J

Exercise Sheet

Decline Board Exercise

- This exercise can be performed without warming up
- The eccentric loading exercises are to be completed by participants twice a day (morning and night) for 12 weeks utilizing a 25 degree wooden decline board.
- Each loading session comprises of 3 sets of 15 repetitions.
- The eccentric (downward) phase of the squat is performed on the symptomatic leg with the knee at approximately 60 degrees flexion.
- The concentric (upward) phase is performed with the asymptomatic leg. Participants are also instructed they can use their arms on a chair to assist the concentric phase if they wish.
- Participants will be guided through the first 4 loading sessions to ensure a consistent 60 degree knee angle and correct technique.

	**Eccentric Phase:** On the symptomatic leg to approx 60 degrees. Instructions are that they take 2 seconds for each downward component, and keep the back straight through the squat. Participants are instructed to exercise into moderate tendon pain which is quantified as a 30-40/100 on the VAS.
	**Concentric Phase:** The upward component on the non-symptomatic leg. Instructions were that participants could also use their arms on a chair to assist the upward movement.

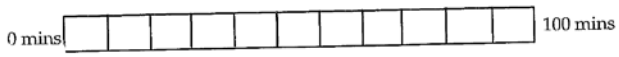
Appendix K

The VISA score - an index of severity of jumper's knee

VICTORIAN INSTITUTE OF SPORT

ASSESSMENT SCALE

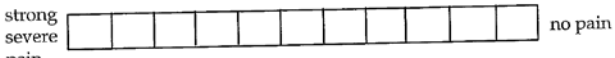
1. For how many minutes can you sit pain free?



0 1 2 3 4 5 6 7 8 9 10

POINTS ☐

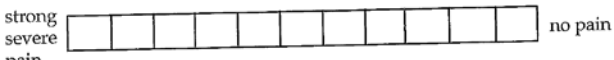
2. Do you have pain walking downstairs with a normal gait cycle?



0 1 2 3 4 5 6 7 8 9 10

POINTS ☐

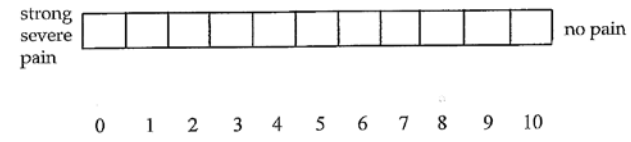
3. Do you have pain at the knee with full active nonweightbearing knee extension?



0 1 2 3 4 5 6 7 8 9 10

POINTS ☐

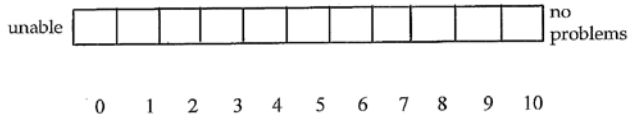
4. Do you have pain when doing a full weight bearing lunge?



POINTS ☐

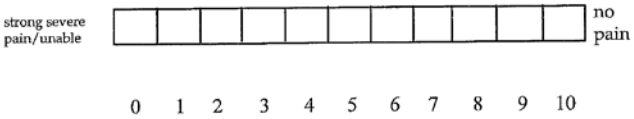
5. Do you have problems squatting?

POINTS ☐



6. Do you have pain during or immediately after doing 10 single leg hops?

POINTS ☐



7. Are you currently undertaking sport or other physical activity?

POIN ☐

0 ☐ Not at all

4 ☐ Modified training ± modified competition

7 ☐ Full training ± competition but not at same level as when symptoms began

10 ☐ Competing at the same or higher level as when symptoms began

8. Please complete **EITHER A, B or C** in this question.

- If you have **no pain** while undertaking sport please complete **Q8a only**.
- If you have **pain while undertaking sport but it does not stop you** from completing the activity, please complete **Q8b only**.
- If you have **pain that stops you from completing sporting activities**, please complete **Q8c only**.

8a. If you have **no pain** while undertaking sport, for how long can you train/practise?

POINTS ☐

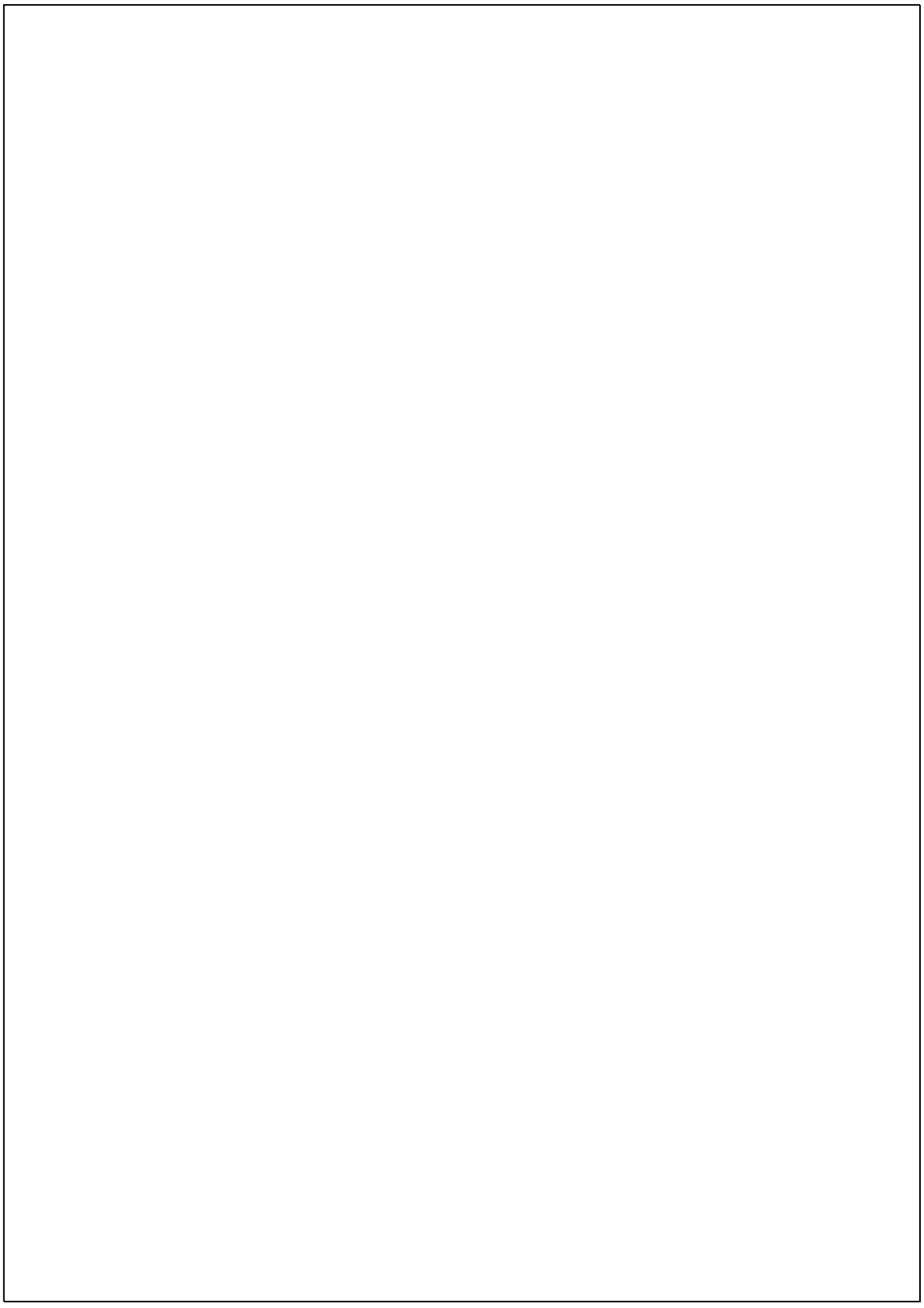
NIL	1-5 mins	6-10 mins	7-15 mins	>15 mins
☐	☐	☐	☐	☐
0	7	14	21	30

OR

8b. If you have some pain while undertaking sport, but it does not stop you from completing your training/practice for how long can you train/practise?

POINTS ☐

NIL	1-5 mins	6-10 mins	7-15 mins	>15 mins
☐	☐	☐	☐	☐
0	4	10	14	20



Appendix L

Ultrasonography is a common technique used to visualize the patellar tendon, and a good method to study the tendon structure (Gisslen & Alfredson, 2005). Warden & Kiss (2007) found both MRI and ultrasonography to be accurate in confirming patellar tendinopathy, but that ultrasonography was the modality of choice. The reliability of ultrasound methods has been indicated to be of high accuracy.

Khan et al (1997) demonstrated ultrasound imaging has perfect reliability in detecting abnormality within the patellar tendon. Grey-scale ultrasonography had greater accuracy than MRI in confirming the clinical diagnosis, whilst a positive colour Doppler ultrasound result indicated that a tendon was symptomatic. Abnormal tendons were defined as those containing a focal hypoechoic region evident in both the longitudinal and transverse images, and/or appearing diffusely hypoechoic and thickened in the proximal tendon.

Weinberg et al (1998) showed that colour Doppler sonography is both sensitive and specific in the diagnosis of patellar tendinosis when compared with gray scale sonography. They stated colour Doppler sonography serves as an adjunct to gray-scale sonography and enables greater confidence in the diagnosis of both normal and abnormal patellar tendons. In a 2 year prospective study looking at Achilles tendinopathy, ultrasound had a sensitivity of 0.8 and a specificity of 0.4, positive predictive value (PPV) of 0.49, and a negative predictive value (NPV) of 0.68 compared to clinical yardstick (Khan et al., 2003).

Studies on chronic painful patellar tendon indicate an association between pain during tendon-loading activity, and the occurrence of vascularisation in the area with structural

tendon changes. In symptomatic patellar tendons, the amount of vascularity has been shown to be associated with the intensity of pain (Gisslen, Gyulai, Nordstrom, & Alfredson, 2007).

The finding that ultrasound features of patellar tendinopathy were equally present in symptomatic and asymptomatic individuals, perhaps highlights the importance of treating the patient rather than the image (Cook et al., 1998). Screening of asymptomatic athletes has clearly shown that changes found on ultrasound and MRI do not correlate with clinical symptoms (Peers & Lysens, 2005). Studies have also shown that evidence of patellar tendinosis on ultrasound can resolve, remain unchanged or expand, without predicting clinical symptoms (Khan et al., 1997). Another longitudinal study examined soccer players before and after a season and concluded that patellar tendinosis seen on ultrasound could not predict symptoms, but represented an increased risk for developing symptoms (Fredberg & Bolvig, 2002).

Several studies have shown that large hypoechoic areas do not change over time (Adriani et al., 1995; Kharjalainen et al., 1997; Sanchis-Alfonso et al., 1999), and similarly tendons used for anterior cruciate ligament graft replacements remain abnormal for years. The inability of a tendon to recover once it reaches the degenerative stage (as per Cook & Purdam's proposed continuum model), is supported by studies that have examined tendons many years after injury or rupture. Although the tendons may improve their function, they do not appear to return to normal size or morphology (Cook & Purdam, 2009). This brings into question the worth of imaging as an outcome measure, or the importance of degeneration with regards to symptoms.

Where practical and affordable, participants in this study were referred to sonographers for both Grey Scale and Colour Doppler Ultrasound. Sonographers were asked to report on abnormality within the patellar tendon, specifically any focal hypoechoic region evident in both the longitudinal and transverse images, and/or appearance of diffusely hypoechoic and thickened areas in the proximal tendon. We also asked that they report on any intrasubstance tears.

Only thirteen of the 28 patellar tendons had an ultrasound scan. Twelve of the 13 scanned tendons were reported as having hypoechoic regions, and neovascularisation was evident in ten of the 13 tendons. Thickening was reported in seven tendons, and 4 were reported as having intrasubstance tears (see Table below).

Eight of the 11 intervention group participants had repeat scans between 5 and 14 months following the intervention period. Each of these scans reported both hypoechoic areas and neovascularisation. Two of these tendons displayed thickening and three had intra-substance tears.

	Control Group	Intervention Group	Follow-Up Scans
Players Scanned	2	11	8
Hypoechoic Areas	2	10	8
Neovascularisation	2	8	8
Thickening	0	7	2
Intrasubstance Tears	0	4	3

Figure 11. Tendon changes seen on ultrasound scan

Figures 12-16 below show ultrasound scans of a player from the EDS group. Baseline USS showed a focal area of reduced echogenicity measuring 40 x 11 x 9 mm deep. Tendon neovascularisation was also present. At baseline, the player scored 64/100 on VISA-P questionnaire.

Follow up scans taken 7 months later showed the same focal area of echogenicity measuring 24 x 11 x 7 mm, as well as neovascularisation affecting the full thickness of the tendon. At follow up scan the player scored 100/100 on VISA-P questionnaire which represents full, pain free function.

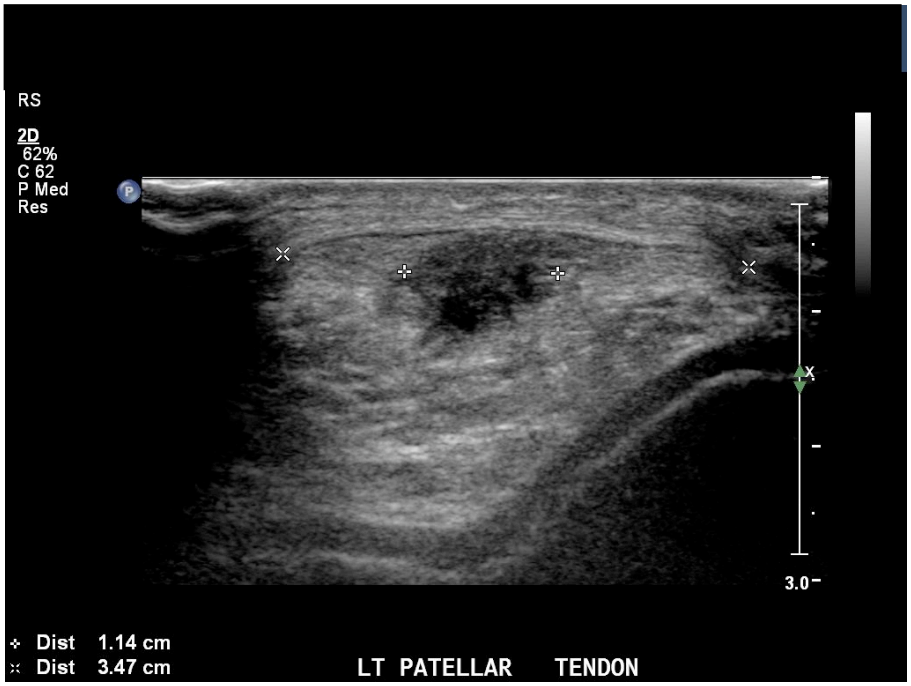


Figure 12. Hypoechoic area in a painful tendon at baseline - transverse view

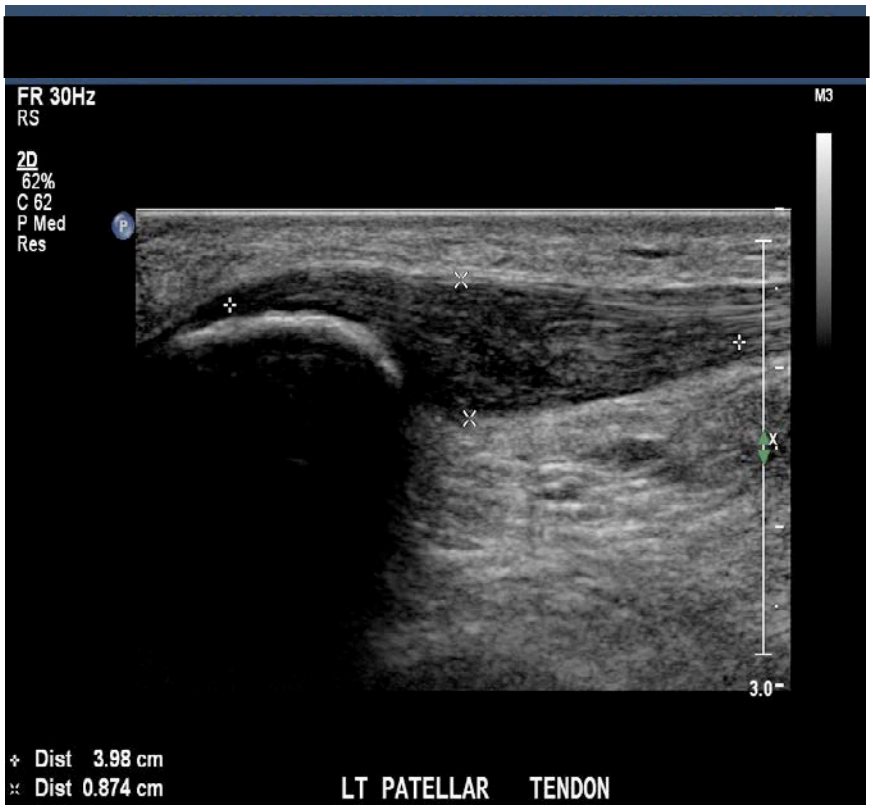


Figure 13. Hypoechoic area in a painful tendon at baseline – longitudinal view

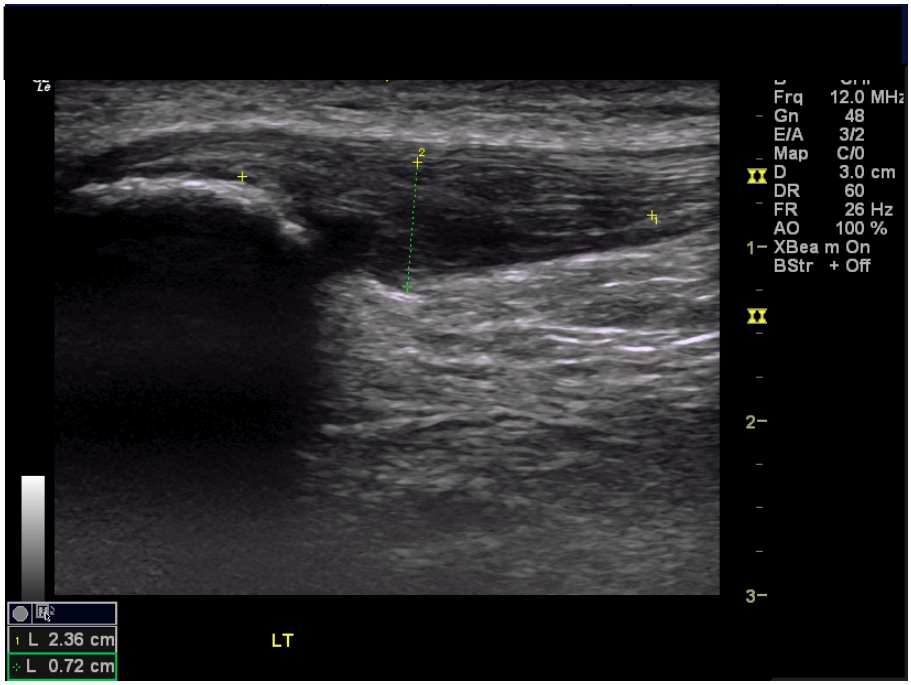


Figure 14. Hypoechoic area at follow up scan – longitudinal view

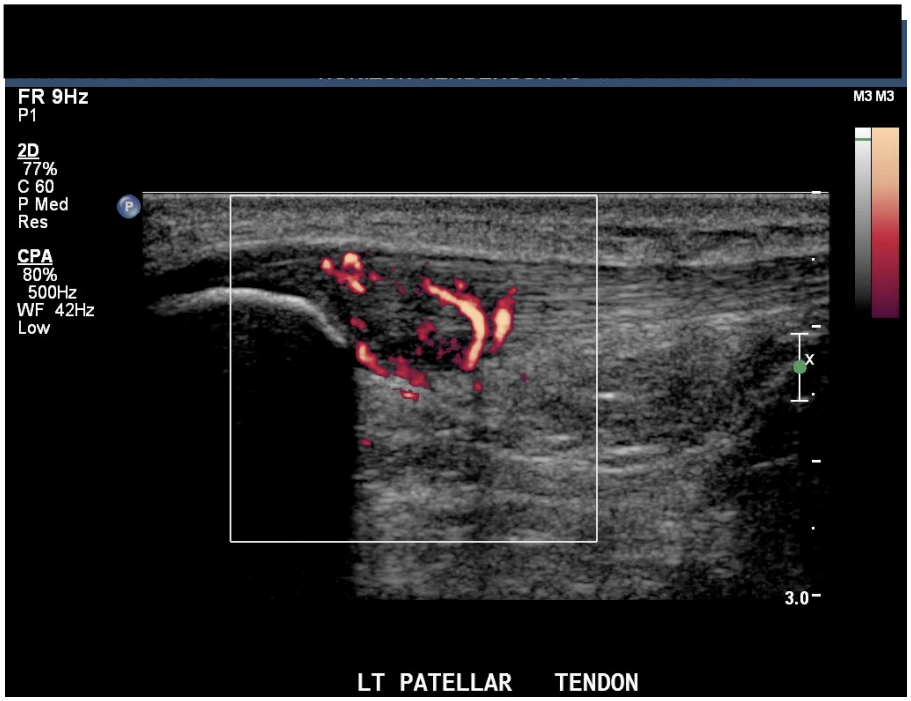


Figure 15. Neovascularisation in a painful tendon at baseline – longitudinal view

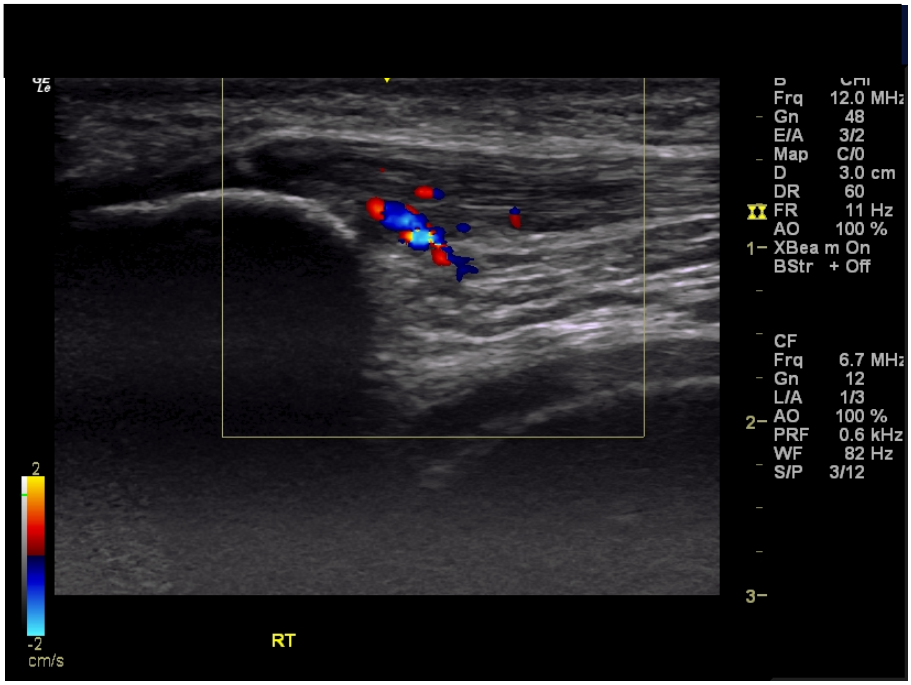


Figure 16. Neovascularisation at follow up scan – longitudinal view

Whilst only 13 of 28 participants were scanned in this study, we found a high percentage showed hypoechoic changes (92%), neovascularisation (77%), thickening of the tendon (54%), intrasubstance tears (31%). Comparing this to the literature on patellar tendon scanning, our study is on a par with Wilberg (2007) and Alfredson (2005). Both looked at 15 patients with long standing patellar tendinopathy and reported 100% with hypoechoic areas and 100% with neovascularisation (Alfredson & Ohberg, 2005; Willberg, Sunding, Ohberg, Forssblad, & Alfredson, 2007).

However with respect to a rugby player population, a recent study assessing patellar tendinopathy in rugby players reported much smaller percentages of change with 29% showing hypoechoic changes, and 26% thickening of the tendon. This study did not report on neovascularisation (Durcan et al., 2014).

Other studies also show variation when comparing findings. Weinberg et al (1998) scanned 14 symptomatic patellar tendons and found neovascularisation in 39%, hypoechoic changes in 39% and tendon thickening in 42%. Comin et al (2013) recorded baseline ultrasound scans of 79 ballet dancers and reported 43% showing hypoechoic changes, 14% displayed neovascularisation, 28% had calcific changes and 29% had intratendon defects. These authors suggested that the presence of focal hypoechoic change, but not other sonographic abnormalities, can predict future development of disabling tendinopathy. A study by Cook et al (2001) imaged a total of 46 asymptomatic patellar tendons and reported 39% of tendons showing hypoechoic changes. They went on to follow-up at 47 months where they reported 5 of 18 tendons became “normal” in appearance. These authors suggested that well recognised hypoechoic areas associated with the clinical condition of patellar tendinopathy can resolve over time. Conversely,

they emphasised that patients with clinical and ultrasound image diagnosis of patellar tendinopathy at baseline can make a full clinical recovery while the ultrasound appearance of their tendon remains abnormal.

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Appendix M

Ratings of Perceived Exertion (RPE), have been shown to be a valid method of quantitating exercise training during a wide variety of types of exercise (Foster et al., 2001). Gabbett & Domrow (2007) examined the relationships between training heart rate and RPE, and blood lactate concentration and RPE, during rugby league trainings. The correlation was 0.89 and 0.86 respectively. In addition they had a subset of players complete two identical training sessions, performed one week apart, to determine test-retest reliability. The intra-class correlation coefficient for test–retest reliability and typical error of measurement for the RPE scale were 0.99 and 4.0% respectively. Collectively, these results demonstrated that the RPE scale offers an acceptable method of quantifying training intensity for collision sport athletes (Gabbett & Domrow, 2007). Training load is calculated by multiplying the training session intensity by the duration of the training session, and is reported in arbitrary units (Foster et al., 2001; Gabbett & Domrow, 2007; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004). As described by Impellizzeri (2004), collecting RPE 30 minutes after training sessions ensures that the perceived effort then reflects the whole session, and not a particularly easy or difficult segment of exercise toward the end of a session, which may dominate or sway the athletes rating (Foster et al., 2001; Impellizzeri et al., 2004). This study has used RPE in an attempt to compare training load and intensity between professional, semi-professional and amateur rugby trainings.

Strength and conditioning staff of the Blues Super 15 Franchise (professional) and Auckland Provincial (semi-professional) sides keep daily records of perceived exertion (RPE) throughout a season, but nothing was found in the literature which looked at RPE in amateur rugby teams.

In this study we used Borg's CR10-scale (Category Ratio Rating of Perceived Exertion Scale), modified by Foster (2001). This scale was modified from its original, to better reflect American idiomatic English (e.g., light becomes easy; strong or severe becomes hard). Briefly, the athlete is shown the scale approximately 30 minutes following the conclusion of the training bout and asked ''How was your workout?'' In their experience, approximately 80–90% of athletes will give a single number representing the training session. The remaining athletes usually insist on fractionating and summating the component parts of the session (Foster et al., 2001).

Rating	Descriptor
0	Rest
1	Very Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	-
7	Very Hard
8	-
9	-
10	Maximal

Table 5. CR 10 Scale (RPE)

Three Premier Grade Rugby teams were selected for involvement in this part of the study. The club physiotherapist and/or trainer, along with the players, were fully informed of the

aims and procedures of the study. The club sides RPE figures were based on 12 weeks in-season with 6 players selected from each of the 3 clubs, giving overall data for 216 weeks of training throughout the 2012 season. Teams trained either 2 or 3 field sessions/week (varied with each team, and coaching staff), and played 1 competitive game/week. Each team had an extended squad of between 30-35 players. The Blues Super 15 rugby side had a full roster of 32 players training throughout this period and the figures given are the average on-field training load including games (weights sessions were removed for the purpose of this comparison). These loads were taken over the 18 “in competition” weeks of the season. The Auckland Provincial side figures were taken over 10 “in competition” games over 10 weeks. The Auckland team roster consisted of 28 players.

Players were taught the CR-10 scale, and taken through the visual descriptors. They were instructed that game day would always be rated as an 8. In typical training sessions players tended to rate basic skills and drills as ‘‘easy’’ (2 on the RPE scale), light contact tackling drills as ‘‘somewhat hard’’ (4 on the RPE scale), full contact tackling drills as ‘‘hard’’ to ‘‘very, very hard’’ (5 – 9 on the RPE scale), and depending on the activity and purpose, skill-based conditioning games as ‘‘moderate’’ to ‘‘very, very hard’’ (3 – 9 on the RPE scale) (Gabbett & Domrow, 2007) (See Table 5).

With club teams, the designated physiotherapist or trainer would get session RPE scores from 6 randomly selected individuals approximately 30 minutes after the conclusion of each training session and each game (RPE scoring sheet – Appendix G). For the first week, the players selected were the 3 forwards and 3 backs who arrived first to training. For the second week players selected were the 3 forwards and 3 backs who arrived last to

training. This first 3 / last 3 concept alternated week about, and these scores were tracked for 12 weeks of in-season training.

The mean weekly RPE scores were; Club sides 1729 (SD 145), Auckland Provincial side 1797 (SD 299), and Blues Super side 1622 (SD 256). One way analysis of variance (ANOVA) revealed no significant difference between the 3 groups (p=0.139) (See Figure 17).

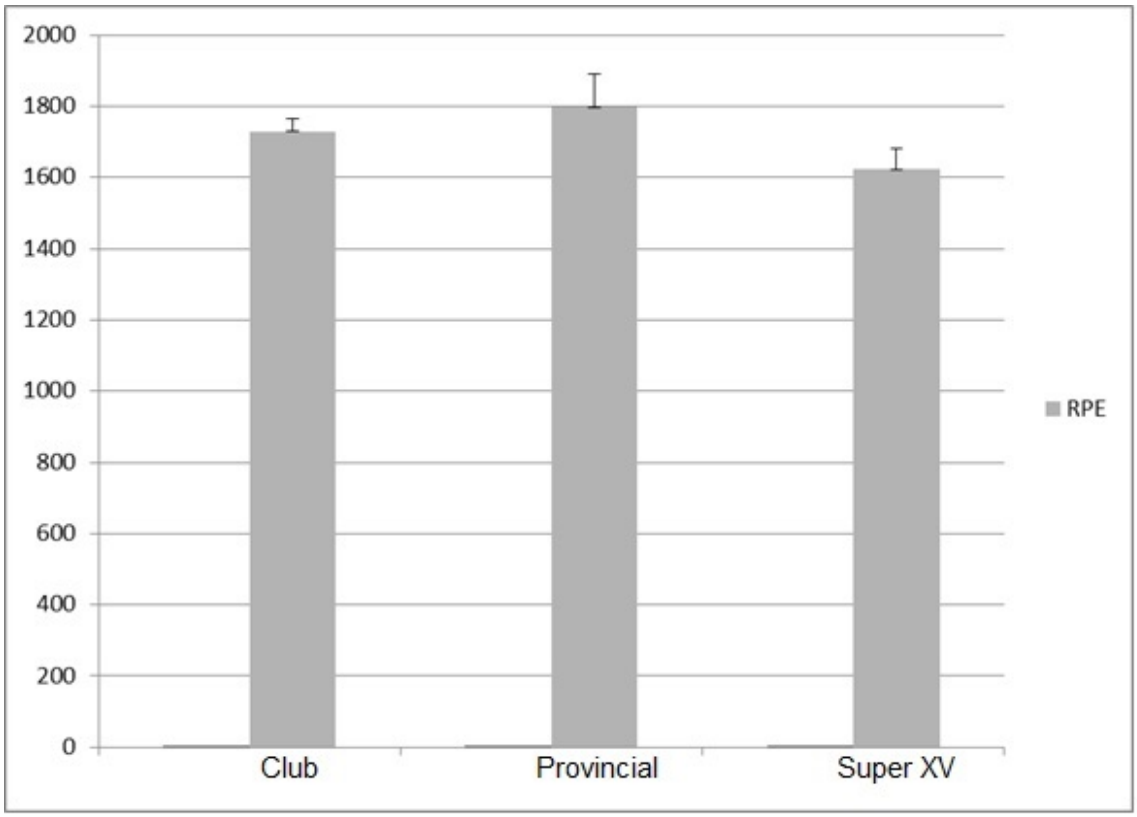

Figure 17. Mean Weekly RPE Scores

With respect to RPE data, our study is original in comparing the weekly on field loadings of amateur, semi-professional and professional rugby union players. Our results revealed

no significant difference between the 3 groups (p=0.139) supporting that weekly on field loading appears not to increase at levels beyond senior amateur club rugby.

Whilst our study looked at overall weekly on field load, Ferretti (1984) found that athletes participating in more than 3 training sessions per week were more susceptible to patellar tendinopathy than those participating in less than 3 training sessions per week, suggesting frequency of training, and not overall weekly load, may be a greater contributing factor (Ferretti & Puddu, 1984). Other studies have also reported a correlation with training volume and frequency, and the development of patellar tendinopathy, and suggested for this reason elite athletes may be more likely to develop patellar tendinopathy than recreational athletes (Ferretti et al., 1983; Gaida et al., 2004; Khan et al., 1998; Lian & Holen, 1996)**.**

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Appendix N

Average Weekly VISA-P Scores

Eccentric Decline Squat Group.

Week

Baseline	1	2	3	4	5	6	7	8	9	10	11	12
65.75 (VISA-P Score)	71.38	78.63	82.01	85.01	87.94	90.5	92.64	93.43	94.07	94.07	94.21	94.5
9.01 (S.D)	11.07	11.71	13.19	12.96	14.99	12.18	12.66	11.45	10.51	10.65	10.48	10.02

Control Group.

Week

Baseline	1	2	3	4	5	6	7	8	9	10	11	12
66.75 (VISA-P Score)	68.42	73.58	74.25	74.92	77	80.1	78.75	78	78	80.25	78.13	81
15.49 (S.D)	16.78	18.12	19.99	19.66	13.86	13.62	19.09	18.62	19.44	17.48	18.32	18.34