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PATELLAR TENDINOPATHY: A REHABILITATION INTERVENTION IN ELITE RUGBY UNION PLAYERS

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ABSTRACT

Patellar tendinopathy is a chronic pathology with a prevalence of 10% to 15% in professional rugby union players. The aim of this study was to determine the outcomes of a 12-week rehabilitation intervention, as proposed by an international e-Delphi panel, in elite rugby union players in South Africa. A pre-test, post-test pilot clinical trial was performed on 16 male participants with patellar tendinopathy. Subjective and objective measurements were performed at baseline and 12 weeks upon completion of the rehabilitation intervention, which included a subjective questionnaire, the Victorian Institute of Sports Assessment – Patella (VISA-P) questionnaire, Visual Analog Scale (VAS) and electromyography (EMG) measurement of three muscles of the quadriceps femoris muscle group. The mean age of the participants was 21.8±1.7 years, with the majority having patellar tendinopathy for the first time and a 75% dominant leg involvement. The duration of symptoms varied between four weeks and six months, with the mechanism of injury identified as jumping, running, change in direction, with increased intensity, frequency and duration aggravating the symptoms. The mean VAS score for pain (p=0.001), quadriceps femoris EMG (p=0.002) and VISA-P score (p=0.001) improved significantly over the 12-week period. The intervention showed a statistically significant improvement in pain and functionality.

***Keywords*:** Patellar tendinopathy; Sport rehabilitation; Elite rugby union players.

INTRODUCTION

Tendinopathy in the lower limbs poses a considerable challenge in any sports population (Barker-Davies *et al*., 2017), with athletes participating in competitive sport having an increased chance of suffering from patellar tendinopathy (Horstmann *et al*., 2017). This condition is a painful pathology of the patellar tendon associated with overuse (De Vries *et al*., 2017) and is classified as a degenerative pathology with no inflammatory process. In the majority of cases, pain is displayed at the inferior pole of the patellar tendon and can be replicated with certain clinical tests and palpation of the patellar tendon (Stasinopoulos, 2016).

Temporary overuse of the patellar tendon may lead to early-onset tissue damage that can return to normal once the load on the tendon is adjusted. Persisting high loads on the patellar tendon, however, may result in the development of chronic pathology, which is an unfavourable outcome (De Vries *et al*., 2017). Between 13% and 20% of elite athletes, whose occupation it

is to compete professionally, are affected by patellar tendinopathy (Kumar *et al*., 2016; Stuhlman *et al*., 2016). Similarly, the era of professionalism in rugby union has been related to an amplified prevalence of injuries, particularly in the knee. The knee accounts for the anatomical structure in the human body sustaining the most injuries in rugby union and is responsible for the most absent days from training (Durcan *et al*., 2014) with a reported incidence of patellar tendinopathy in rugby players of 10% to 15% (Barker-Davies *et al*., 2017).

Talented young rugby players are stationed at elite rugby academies and unions, competing and training at high levels with increased volume, intensity and frequency (Durcan *et al*., 2014). In these players, the main mechanism of injury responsible for patellar tendinopathy is mechanical overload of the patellar tendon (Taş *et al*., 2017), which may lead to weakness of the tissue and sometimes catastrophic failure of the tendon (Schwartz *et al*., 2014). These advanced training regimes are responsible for the more frequent prevalence of patellar tendinopathy as a chronic injury (Wilson *et al*., 2014). Despite the increasing prevalence, chronic injuries in rugby union are reported less frequently in the literature than acute injuries (Durcan *et al*., 2014).

Patellar tendinopathy can have an adverse effect on the economic position and the quality of life of elite rugby union players (Castro *et al*., 2016). Although patellar tendinopathy is a common chronic pathology in rugby union (Wilson *et al*., 2014) with well-defined medical signs and symptoms (Stasinopoulos, 2016), a paucity of evidence and data are available in the literature regarding the treatment of elite rugby players with this injury (Fairley *et al*., 2014). It has an erratic nature by virtue of its poor association between pain, function and pathological stage, a situation that necessitates critical planning for the elite rugby player involved (Barker-Davies *et al*., 2017).

A diversity of treatment options is available for patellar tendinopathy, however, no specific ideal treatment modalities that assure comprehensive recovery have been described in the literature, and the symptoms can often become long-term (De Vries *et al*., 2017). Even with contemporary treatment, the symptoms do not resolve rapidly, with the majority of athletes experiencing long-lasting symptoms for up to 32 months (Fu & Tsang, 2017). Stuhlman *et al*. (2016) described this tendency as unacceptable in today's competitive sport environment, which warrants continuous investigation of this pathology.

This limited availability of research and evidence within the elite rugby union clinical environment, as well as the continuous poor and disappointing outcomes of patellar tendinopathy rehabilitation, necessitated this investigational study. A 12-week rehabilitation intervention was developed based on the findings of an international e-Delphi survey (Morgan *et al*., 2018). This article reports on the exploratory implementation of the proposed rehabilitation intervention among elite rugby players of a South African rugby union.

METHODS

A pre-test, post-test pilot research design was utilised in this study to determine the outcomes of the international e-Delphi based rehabilitation intervention on patellar tendinopathy symptoms (Morgan *et al*., 2018). The study population consisted of elite rugby union players having professional rugby as their occupation. Due to ethical considerations and to provide each

player with the opportunity to receive the best effective treatment to continue successfully with their professional careers, the group was not divided into an experimental and control group.

Study population

The sample consisted of 16 elite rugby union players who met the inclusion criteria for the study (Table 1).

***Table 1*. INCLUSION AND EXCLUSION CRITERIA FOR SELECTION OF PARTICIPANTS**

Inclusion criteria	Exclusion criteria
Diagnosed with patellar tendinopathy Pain or tenderness of patellar tendon affecting their performance in rugby A squat or a jump test that leads to patellar tendon pain 18 years or older English literate	Any previous knee surgery or other knee pathologies, except patellar tendinopathy Bilateral patellar tendinopathy Other concurrent lower limb pathologies

Ethical considerations

Ethical clearance was obtained from the Ethics Committee of the Faculty of Health Sciences at the University of the Free State, South Africa (ECUFS181/2015) before commencement of the study. The rugby medical manager and all the participants provided written informed consent and participation was voluntary.

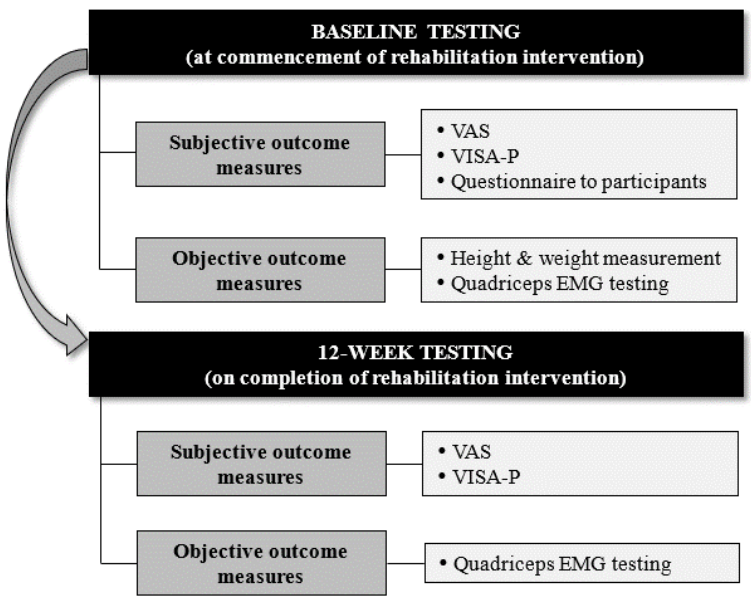
Data collection

The research and data capturing were conducted in Pretoria, South Africa. The rugby union medical manager (team physician) was informed about the study and requested to identify injured elite rugby players with patellar tendinopathy. The players were also informed about the contribution they could make should they be willing to participate in the research study. An appointment was arranged between the injured players and the principal researcher (S.M.) at a suitable venue. The first appointment was one hour and the follow-up sessions were 30 minutes.

A subjective questionnaire compiled by the researcher was used to capture demographic information, injury pattern of patellar tendinopathy, load tolerance and level of sport participation. Secondly, knee pain and functionality of the elite rugby players were subjectively measured by means of the Visual Analog Scale (VAS) and the Victorian Institute of Sport Assessment – Patellar (VISA-P) questionnaire, which have shown respectable reliability and validity in research (Vetrano *et al*., 2013). The objective outcomes measures included height and weight measurements according to the International Standards for Anthropometric Assessment (ISAK, 2001), and surface electromyography (EMG) of three muscles of the quadriceps femoris.

Bipolar configuration quadriceps femoris EMG (mV) testing was performed during a maximal voluntary contraction of the vastus medialis oblique (electrode placement: 4/5 from the anterior spinae iliaca to the joint space before the anterior border of the medial collateral ligament), vastus lateralis oblique (electrode placement: ⅔ from the anterior spina iliaca to the lateral border of the patella) and rectus femoris muscle (electrode placement: mid-point from the anterior spinae iliaca to the superior border of the patella) (Hu *et al.,* 2006) during a single leg 25º decline squat (Balachandar *et al*., 2011). The input impedance was minimised and the electrode placement and location were in accordance with the Surface EMG for Non-Invasive Assessment of Muscles (SENIAM) (Scurr *et al*., 2011). The surface electrodes were 50 X 50mm^2 and 2cm apart, with the ground electrode placed on the ipsilateral proximal tibial tuberosity. EMG data were recorded at a synchronous channel at a frequency of 10 Hertz.

Figure 1 is a diagrammatic representation of the measures performed at baseline (prior to commencement of the rehabilitation intervention) and at 12 weeks (after completion of the intervention).



VAS=Visual Analog Scale VISA-P=Victorian Institute of Sport Assessment – Patellar questionnaire

Figure 1. **SUBJECTIVE AND OBJECTIVE OUTCOMES MEASURES**

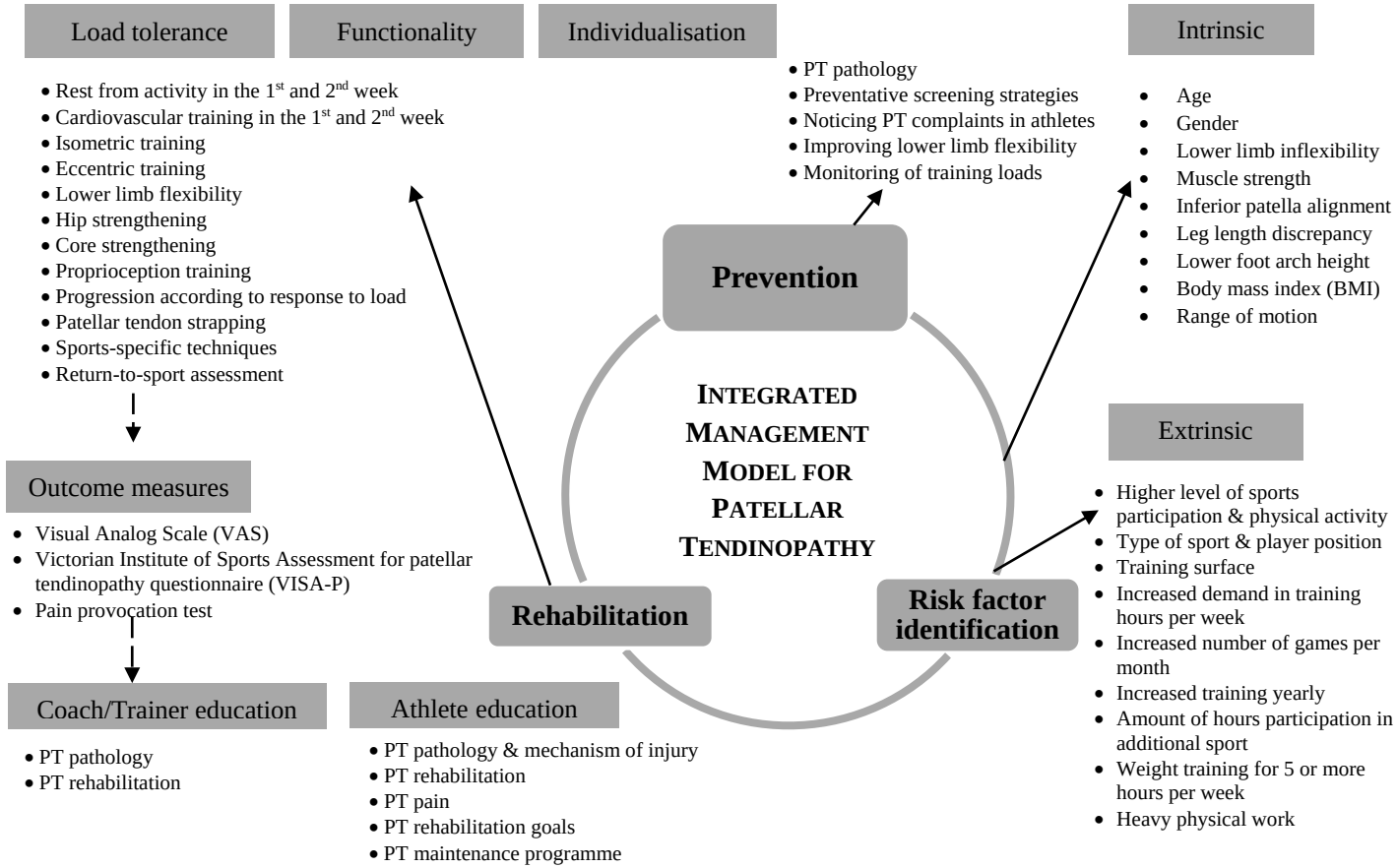


Figure 2. **AN INTEGRATED MANAGEMENT MODEL FOR PATELLAR TENDINOPATHY**

Rehabilitation intervention

The proposed integrated management model for patellar tendinopathy (Figure 2) was designed and developed by the researchers, based on the models of Bahr and Krosshaug (2005), Meeuwisse *et al.* (2007) and Brukner and Khan (2012) and further supplemented with the findings of the systematic review on the causative risk factors and rehabilitation for patellar tendinopathy (Morgan *et al*., 2016) and the international e-Delphi survey (Morgan *et al*., 2018).

This model is presented in Figure 2 and consists of three core elements: risk factor identification, prevention and rehabilitation. Only the elements of rehabilitation identified by means of the e-Delphi rehabilitation framework (Morgan *et al*., 2018) were implemented and applied in the clinical set-up of the elite rugby players and discussed in this article. The other two supplementary core elements, namely risk factor identification and prevention, were discussed in Morgan *et al*. (2016). According to the model, the three key aspects of rehabilitation that were applied to this study are load tolerance of the patellar tendon during any activity, functional ability of the elite rugby player and individualisation of the rehabilitation intervention to address the specific biomechanical and rehabilitation needs of the elite rugby player. The load tolerance principle is superior to the other two themes and implies that pain on the provocation test must return to baseline within 24 hours after activity or rehabilitation. This would indicate that the patellar tendon has tolerated the load (Malliaras *et al.*, 2015). The entire rehabilitation intervention, regardless of the activity, was guided by this central principle.

The three key aspects comprise subcomponents which are the secondary components of the rehabilitation intervention. These components of the rehabilitation intervention consist of rest in the 1st–2nd week from any lower limb physical activity that aggravates the symptoms of the pathology, cardiovascular training (swimming) in the 1st–2nd week that does not put load on the patellar tendon to assist in fitness maintenance, lower limb flexibility/stretching, isometric training of the quadriceps femoris muscle, eccentric training of the quadriceps femoris muscle, lower limb flexibility/stretching, hip muscle strengthening, core muscle strengthening, lower limb proprioception training, progression of the rehabilitation programme based on load tolerance, patellar tendon strapping, sport-specific techniques, return-to-sport assessment and athlete, trainer/coach education (Morgan *et al*., 2018). All these components were integrated into an encompassing individualised rehabilitation intervention for each elite rugby player. The elite rugby players were exposed to three rehabilitation sessions per week each lasting 30 minutes, for a duration of 12 weeks. Each session of the 36 sessions were documented.

Statistical analysis

Quantitative variables, such as weight and body mass index (BMI) for forwards and backline players were obtained and compared using the Student t-test. A result was deemed significant (null hypothesis of equality was rejected) when the p-value for the test was less than 0.05. The scores obtained from the VISA-P and the VAS questionnaires as well as the EMG results at baseline were compared with the corresponding measurements after the 12-week rehabilitation intervention using a binomial sign test (Hogg & Tanis, 1997). This is a nonparametric test for paired data and indicates whether the median VISA-P, VAS and EMG scores changed over the 12-week intervention period.

RESULTS

The study included 16 elite male rugby players (mean age of 21.8±1.7 years; range 19–26 years) with confirmed signs and symptoms of patellar tendinopathy. They all successfully completed the 12-week rehabilitation intervention programme without any participant dropouts or rehabilitation sessions missed. The participants were homogeneous with respect to training regime, with 37% being involved in international and 63% in provincial level of sport participation.

Table 2. **SPECIFIC INJURY PATTERNS SELF-REPORTED**

Variable	n (%)
Player position	
• Forward	8 (50.0)
• Backline	8 (50.0)
Leg dominance and PT	
• Dominant leg	12 (75.0)
• Non-dominant leg	4 (25.0)
Injury history	
• New injury	12 (75.0)
• Recurring injury	4 (25.0)
Onset of symptoms	
• Acute onset	0 (0)
• Gradual onset	16 (100)
Duration of symptoms	
• 1–2 weeks	0 (0)
• 2–4 weeks	0 (0)
• 4–8 weeks	4 (25.0)
• 8–12 weeks	5 (31.25)
• 3–6 months	3 (18.75)
• More than 6 months	4 (25.0)
Mechanism causing injury	
• Jumping	15 (93.75)
• Running	14 (87.5)
• Change in direction	13 (81.25)
• High volume training	12 (75.0)

Notable differences were observed between forward and backline players. Their overall mean body weight was 93.5±13.5kg (range 75–118kg) and their mean BMI was 27.2±3.5kg/m^2 (range: 20.9–33.7kg/m^2). The forward players (n=8) had a higher mean weight of 101±12.9kg (range: 79–118 kg) and a BMI of 29.0±3.1kg/m^2 (range: 25.6–33.7kg/m^2), compared to the backline players (n=8) with a mean weight and BMI of

86±9.4kg (range: 75–104kg) and 25.4±3.2kg/m^2 (range: 20.9–29.7kg/m^2), respectively. The specific injury patterns for the study participants are presented in Table 2.

Outcome measures

The mean VISA-P score at baseline was 37.1±16.2 (range: 10–67). When the group was stratified by player position (forward or backline player), a mean VISA-P score at baseline of 29.6±13.1 (range: 10–48) for forwards and 44.5±16.2 (range: 21–67) for backline players was obtained, which was significantly different (p=0.032). After the 12-week rehabilitation intervention, the overall mean VISA-P score increased to 66.6±16.5 (range: 25–89). The mean VISA-P score of the forwards increased to 60.1±20.0 (range: 25–89) and the backline players to 73.1±9.2 (range: 59–84), which was also a relatively substantial difference between forward and backline players (p=0.063). The VISA-P score improved for all 16 players over the 12-week rehabilitation period, with a significant (p=0.001) mean increase of 29.5±20.4 (range: 8–69) in the score.

Table 3. **EMG FINDINGS: QUADRICEPS MUSCLE AT BASELINE AND AFTER COMPLETION OF 12-WEEK REHABILITATION INTERVENTION**

Muscle groups	Muscle: EMG findings (mV) Baseline	After 12 weeks	p-Value
Mean work average			
Vastus medialis oblique	60.1±32.3 * (24.6–127.9)	79.6±45.7 * (31.4–207.1)	0.004
Rectus femoris	52.0±47.9 * (7.8–189.4)	71.1±42.3 * (25.7–164.3)	0.004
Vastus lateralis oblique	61.3±32.1 * (17.2–124.5)	79.8±38.2 * (38–167.3)	0.001
Mean work peak			
Vastus medialis oblique	415.8±390.8 * (94–1554)	541.6±417.5 * (146–1842)	0.001
Rectus femoris	285.4±174.4 * (41–654)	454.0±201.1 * (235–881)	0.001
Vastus lateralis oblique	302.6±99.0 * (107–427)	454.0±201.1 * (235–881)	0.001

* Range of scores (min – max)

Two questions on the VISA-P regarding the experience of pain during a full weight-bearing lunge and a squat were analysed separately for forward and backline players. The mean pain rating of the lunge exercise at baseline was 1.6±0.8 (range: 1–3) for forwards and 3.3±1.6 (range: 1–6) for backline players, which was a statistically significant difference (p=0.019). After the 12-week rehabilitation intervention, the mean scores improved significantly (p=0.020) for both forwards and backs to 5.8±2.4 (range: 1–8) and 7.9±1.3 (range: 5–9), respectively.

Equally, the mean pain rating of the squatting exercise at baseline was significantly different (p=0.028) between the forwards (mean score 1.5±1.0; range 1–3) and backline players (mean score 2.8±1.3; range 1–5). After the 12-week rehabilitation programme the mean scores improved (p=0.12) for both the forwards and backline players to 6.5±2.0 (range: 2–8) and 7.6±1.7 (range: 6–10) respectively.

The VAS questionnaire measures pain in athletes with patellar tendinopathy (Da Cunha *et al*., 2012), with higher scores indicating a greater degree of pain. The overall mean VAS score for the elite rugby players at baseline was 7.9±1.3 out of 10 (range: 5–9 out of 10), while after the 12-week rehabilitation intervention, the mean score was significantly lower (p=0.001) at 2.3±1.5 out of 10 (range: 1–7 out of 10).

As summarised in Table 3, the EMG on work average and work peak for the vastus medialis oblique, rectus femoris and vastus lateralis muscles all showed a significant improvement from baseline to after the 12-week intervention programme (p=0.002).

DISCUSSION

The profile of the participants in this study with patellar tendinopathy showed resemblance with profiles previously described in the literature with regard to BMI, gradual onset of symptoms, reoccurrence of the pathology and mechanism of injury (Ferretti *et al*., 2002; Durcan *et al*., 2014; Reinking, 2016; Stuhlman *et al*. 2016).

The mean BMI of the forward rugby players was significantly greater than that of the backline players, which is similar to results reported by Durcan *et al*. (2014). This finding could be attributed to the fact that forward players are expected to be heavier than the backline players to meet the requirements of functional positional play (Duthie *et al*., 2003). This BMI finding also agreed with previous reports on patellar tendinopathy, which specified that an elevated body weight and BMI are potential risk factors for patellar tendinopathy (Durcan *et al*., 2014; Schwartz *et al*., 2014).

Patellar tendinopathy occurred in the dominant leg in 75% of the elite rugby players in this study, despite the opposite being found by Hägglund *et al*. (2011), where 40% of patellar tendinopathy injuries were recorded in the dominant leg of football athletes, and 48% in the non-dominant leg.

The outcomes of the subjective baseline questionnaire disclosed a recurrence rate of this pathology in 25% of the elite rugby players. According to Stuhlman *et al*. (2016), the reoccurrence rate of patellar tendinopathy symptoms is 23% in athletes who already completed an extensive, intensive rehabilitation programme. This literature corresponds with the results of this study and supports the statement by Reinking (2016) that patellar tendinopathy is a challenging pathology to treat.

The onset and duration of patellar tendinopathy symptoms in this study showed a relation to previous literature. Gradual onset of patellar tendinopathy symptoms was a prominent finding. It is typical to the nature of chronic injuries (Brukner & Khan, 2012) that have a slow onset, especially patellar tendinopathy (Reinking, 2016). The symptoms of patellar tendinopathy are often deceptive (Rosso *et al*., 2015) and unexpected, with a repetitive

onset (Sànchez-Ibàñez, 2015). This study showed the duration of symptoms to be prolonged in some of the elite rugby players with 19% experiencing symptoms for between three and six months and 25% with persisting symptoms for six months or more. It was similar to previous studies reporting that patellar tendinopathy is characterised by lengthy (Sànchez-Ibàñez, 2015) anterior knee pain (Vetrano *et al*., 2013), with one third of the athletes affected by patellar tendinopathy experiencing symptoms and limitations (Saithna *et al*., 2012) and being unable to return to sport for a period of six months or longer (Stuhlman *et al*., 2016).

Jumping, running, change of direction and intense training regimes were contributing factors to the mechanism of injury in this study. It has been reported that patellar tendinopathy is associated with rapid deceleration, acceleration (Ferretti *et al*., 2002), jumping (Zhang *et al*., 2014) and landing on the lower extremities (Ferretti *et al*., 2002). Excessive mechanical overload on the patellar tendon (Rosso *et al*., 2015) that exceeds its reparative capacity (Rowan & Drouin, 2013) is a distinctive factor for the development of patellar tendinopathy (Rosso *et al*., 2015). The results also confirmed that an increase training volume is associated with patellar tendinopathy (Durcan *et al.*, 2014) and modern elite rugby players are involved in increased volume, intensity and duration of training and competitions (Durcan *et al*., 2014). The current study found that increased intensity (100% incidence), frequency (94% incidence) and duration (100% incidence) contributed to the amplified load on the patellar tendon, which supports Hägglund *et al*. (2011) who identified increased load as an extrinsic causative risk factor for patellar tendinopathy.

Electromyography

The EMG testing on the three muscles of the quadriceps femoris in our study participants provided noteworthy findings based on the values obtained (Table 3). The single leg 25º decline squat provided improved activation results after the 12-week rehabilitation intervention with significantly greater muscle recruitment. It has been reported previously that a single-legged squat on a 25º board is associated with clinical improvements in patellar tendinopathy athletes (Ribeiro *et al*., 2007). Furthermore, the literature specifies that successful rehabilitation programmes include strength training, which reduces pain and facilitates return to sport (Rio *et al*., 2015), with quadriceps femoris muscle strength and endurance one of the vital aspects for normal knee joint function (Hart *et al*., 2010).

These results confirm that the rehabilitation intervention made a statistically significant difference in the mean scores of the VAS and VISA-P at baseline compared to 12 weeks after intervention. This research did not determine the precise rehabilitation component in isolation that was accountable for the major improvement, but rather illustrated that a variety of rehabilitation components were responsible for the significant improvement of the symptoms in the elite rugby players. Therefore, it can be argued that conservative treatment, especially exercise, is still the leading approach to rehabilitation intervention for patellar tendinopathy (Schwartz *et al*., 2014) and plays a key role in the recovery process of elite rugby players. The load tolerance principle was the cornerstone of this study, which highlights again that traditional rehabilitation approaches are evidence-based (Reinking, 2016).

Functionality

The VISA-P score improved for all 16 participants over the 12-week rehabilitation period. This finding relates to literature describing that athletes affected by patellar tendinopathy experience increased pain and impaired functionality (Rosso *et al*., 2015), but the symptoms will improve with rehabilitation (Rudavsky & Cook, 2014). Initially, the forward players had an overall lesser functionality based on their mean VISA-P score than backline players, which agrees with previous findings reported by Durcan *et al*. (2014).

One can reason that both forwards and backline players perform core skills, such as tackling and rucking, but there is a variation in movement patterns, physical condition in terms of BMI and skill demand for forwards and backline players. This implies that forward players are more involved in set play aspects, such as scrum and lineouts (Tee & Coopoo, 2015). This set play of rugby movements is related to the mechanism of injury of patellar tendinopathy and may clarify the lower VISA-P score seen in forwards compared to backline players at baseline. It is also reflected in the VISA-P specific questions that evaluated functional movements screening, such as squat and lunge, where the forward players' functional movements scores were significantly lower than the backline players at baseline. This type of activity forms a key aspect of set play in a forward rugby player position.

Pain

After completion of the 12-week rehabilitation intervention, improvement in symptoms and pain was a prominent outcome. A significant reduction in pain ($p<0.001$) was found when comparing baseline pain to the degree of pain after a 12-week rehabilitation intervention. This finding agrees with a statement of Rudavsky and Cook (2014) that an active exercise rehabilitation intervention with slow progression will reduce pain in athletes with patellar tendinopathy.

Another notable finding from the current study was the trend that decreased muscle activation results on the EMG at baseline seemed to accompany lower scores on the VAS and VISA-P, an indication that insufficient muscle strength and inability to control the muscle activity could be linked to an undesired outcome, such as pain and poor performance (Rio *et al*., 2015). This further highlights the fact that pain and functional dysfunction on the VAS and VISA-P scores were associated with load on the tendon, which was responsible for provoking symptoms (Zhang *et al*., 2014). Taking into consideration that the central focus of the rehabilitation intervention was the load tolerance principle, it once again emphasises that load tolerance plays an important role in patellar tendinopathy rehabilitation and was a contributing factor in obtaining positive results in this study.

CONCLUSION

The limited research on patellar tendinopathy within the elite rugby union environment, as well as the continuous poor outcomes of PT rehabilitation, necessitated further investigation of this pathology. Building on an initial compilation of a 12-week rehabilitation intervention based on the findings of an international e-Delphi survey, this article reports on the exploratory implementation of that intervention among elite rugby

players of a South African rugby union. The rehabilitation intervention was founded on three principles, namely the functional ability of the elite rugby player, individualising the rehabilitation intervention according to the participant's specific biomechanical deficiencies and load tolerance of the patellar tendon. The outcomes of this study demonstrate improvement in pain and functionality in elite rugby union players with patellar tendinopathy.

STRENGTHS, LIMITATIONS AND RECOMMENDATIONS

One of the strengths of this study lies in the e-Delphi survey experts' opinions (Morgan *et al*., 2018), which led to the development of this intervention model that outlined promising results in terms of decreased pain and increased functionality. A limitation identified in this study was the exclusion of participants with bilateral patellar tendinopathy involvement, and the exclusion of a long-term follow-up of participants, which could be addressed in future research. A follow-up study is recommended with a larger study population and with the inclusion of a number of other variables, such as a distinction between junior and senior elite rugby players, as well as in- and out-season rehabilitation.

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