ORIGINAL ARTICLE

Prospective study of change in patellar tendon abnormality on imaging and pain over a volleyball season

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Br J Sports Med 2006;**40**:272–274. doi: 10.1136/bjsm.2005.023846

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Received 11 October 2005
Revised 11 October 2005
Accepted
22 November 2005

Objective: Patellar tendon injury, defined by tendon abnormality (TA) on imaging and by pain, is common among volleyball players, but little is known about change in this injury over a volleyball season. Increased activity in the season compared with the off season may result in the development of TA and/or pain. This study investigated the behaviour of TA and pain over a competitive volleyball season.
Methods: Tendon abnormality and pain were measured in 101 volleyball players at the beginning and end of a season. Pain was measured with the single leg decline squat test, which loads the patellar tendon, and TA was detected with ultrasound imaging. Hours of weekly activity were measured and compared during the season and the off season. The proportion of tendons that underwent development and resolution in TA and/or pain over the season was investigated.
Results: Hours of weekly activity was greater during the season than in the off season. Most of the tendons investigated (66.3%) did not undergo a change in TA or pain over the season. Tendon abnormality and/or pain developed in 16.6% of tendons and resolved in 11.2%.
Conclusions: The tendons of volleyball players respond variably to the increased load over the season. Change in TA and pain does not appear to be entirely dependent upon load.

There is a high prevalence of overuse injury to the patellar tendon among volleyball players. Patellar tendinopathy, which is characterised by tendon abnormality (TA) on imaging and by pain, is the most common patellar tendon injury.[1] Studies among volleyball players indicate that 27% of competing volleyball players may be affected by this injury.[2] Additionally, TA without pain has been shown to affect 13.5% of volleyball players' patellar tendons.[3]

Tendon load has been implicated in the development of TA with and without pain. Tendon pathology may develop following a failed attempt to adapt to increased load.[4] Biochemical[5] and neurogenic[6] processes involved in tendon pain may also be stimulated by load. Studies in the literature showing an association between tendon load and abnormality on imaging with or without pain support these theoretical arguments.[7–9]

During the season, volleyball players are likely to experience a transition from less to more jumping activity, and this may increase the risk of developing TA and/or pain.[10] This would clearly indicate that load affects tendons during the season and have consequent implications for the prevention and treatment of patellar tendon injury.

There is to date little empirical evidence concerning change in TA and pain over the season. Fredberg *et al*[11] investigated 54 elite male soccer players over the pre-season and on season, and found that 17% of tendons with abnormality but no pain developed pain and 33% were normal at the end of the season. Studies among elite basketball players with follow up periods of 16–48 months also report that tendons with TA may develop pain or become normal over time.[12–14] It remains to be seen whether TA on imaging and pain are more likely to develop over a volleyball season when players compete regularly and activity level is likely to be increased.

Studies in the literature also show that normal tendons are more likely to develop TA without pain (10–18%) than TA with pain (2–7%).[13 14] This suggests that an ordinal relationship may be assumed between the development of TA and pain.[10] It is not known whether pain resolves before TA in tendons containing both of these features.

The current literature is also limited regarding the propensity of men and women to develop TA on imaging over time. Cook *et al*[14] reported that over an average follow up of 16 months, adolescent male basketball players were more likely to develop TA than their female counterparts; however, this relationship has not been investigated among adult players. Additionally, little is known about change in the intensity of pain (an indicator of change in injury severity) among players with TA on imaging and pain.

The principal aim of this study was to investigate the development and resolution of TA and pain over a volleyball season. Secondly, development of TA was compared between men and women. Thirdly, the intensity of pain was measured among athletes who had TA with pain that did not resolve over the season.

MATERIALS AND METHODS

Subjects

A convenience sample of men and women was recruited from the Victorian State League volleyball competition in Australia. Players were excluded if they were <18 years of age, because self limiting juvenile injuries such as Osgood-Schlatter disease may be difficult to differentiate from patellar tendon injury.[1] Ethics approval was granted from the human ethics committee at La Trobe University, and participants gave informed consent before commencement of the study.

Activity level

Activity level was measured over 12 months, including 7 months prior to the commencement of the season and during the season. Players completed fortnightly diaries that recorded the number of hours of training and playing each week. The time period of 2 weeks was chosen for diary completion because it was considered short enough to minimise errors due to inaccurate recall.[15] Activity during the season and the rest of the year was calculated by

Abbreviations: SLDS, single leg decline squat; TA, tendon abnormality

Table 1 Transition in the groups

Beginning of the season	End of the season				
	Normal	TA w/o pain	TA with pain	Pain w/o TA	Total
Normal tendon	48 (65.8)	18 (24.7)	1 (1.3)	6 (8.2)	73 (100)
TA w/o pain	6 (13.3)	28 (62.2)	9 (20.0)	2 (4.5)	45 (100)
TA with pain	2 (4.0)	11 (21.5)	36 (70.6)	2 (3.9)	51 (100)
Total	56 (33.2)	57 (33.7)	46 (27.2)	10 (5.9)	169 (100)

Data are frequency (proportion). TA, tendon abnormality; w/o, without.

averaging the hours of weekly activity (training and playing) over the number of weeks in each period.

Ultrasound imaging

Tendons were imaged with ultrasound to detect TA at the beginning (first month) and end (fifth month) of the volleyball season. Ultrasound imaging was chosen over magnetic resonance imaging for the large clinical cohort because of its lower cost and portability.[16] Ultrasound imaging has demonstrated perfect reliability in detecting patellar TA among basketball players.[12]

Bilateral patellar tendon scans were performed by a single experienced musculoskeletal ultrasonographer with a high resolution 12 MHz ultrasound machine (Siemens Accuson; Medical Solutions Inc., Malvern, PA, USA). The ultrasonographer was blinded to the players' pain assessment findings. Tendon abnormality was characterised by a hypoechoic region and/or diffuse thickening in the proximal tendon in both longitudinal and transverse images.

Clinical assessment of pain

Pain was assessed at the beginning and end of the volleyball season with the single leg decline squat (SLDS) test, which was designed to preferentially load the patellar tendon.[17] Participants performed a single leg squat to 60° of knee flexion on a 25° decline board and rated the pain provoked on a 100 point visual analogue scale. The standard error on repeated measurement with the SLDS test has also been shown to be 5% (range 4.1 to 6.2%).[17] The SLDS test may offer greater construct validity as a measure of pain arising from the patellar tendon than measures such as the site of pain[3 9 18] and tenderness on palpation,[19] which are likely to be inaccurate in the presence of referred pain.

Outcome variable

Three groups were formed by combining TA and pain: (*a*) normal tendon (no TA or pain), (*b*) TA without pain, and (*c*) TA with pain. Painful tendons without TA were excluded because in this situation, it is likely that pain is not arising from the patellar tendon.[1]

Data analysis

For each group, the frequency and probability of development and resolution in TA and/or pain was investigated. This corresponded to the frequency and probability of no change and change into each of the other groups. These Markov transition probabilities reflect the probability of transitioning from one state at time one to the same or different state at time two.[20] Change in the groups was also dichotomised into tendons that developed TA and/or pain, and tendons that experienced resolution in TA and/or pain.

Activity level during the season and the rest of the year and the intensity of pain at the beginning and end of the season among players with TA with pain throughout the season were compared with an independent samples *t* test. The development of TA with and without pain among normal tendons was compared between men and women using the χ^2 test.

Table 2 Normal tendons (baseline) in men and women that remained normal or developed tendon abnormality with or without pain

	End of the season	
	Normal	TA with or without pain
Men	25 (67.6)	12 (32.4)
Women	23 (76.7)	7 (23.3)

Data are frequency (%). TA, tendon abnormality.

RESULTS

The sample comprised 94 players (169 tendons, 75 bilateral) with a mean (SD) age of 26.2 (5.3) years, mean bodyweight of 80.0 (13.2) kg, and mean height of 1.82 (0.10) metres. At baseline, 43.2% of tendons were normal, 26.6% had TA without pain, and 30.2% had TA with pain. The players trained and played for a greater number of hours per week ($t_{336} = 10.34$, $p<0.01$) during the season (mean (SD) 4.94 (1.48) hours) compared with the off season (mean (SD) 3.14 (1.71) hours).

The frequency and proportion of tendons that changed and remained unchanged in each group is shown in table 1. Most of the tendons investigated (66.2%) did not undergo a change in TA or pain over the season; 10% of tendons were painful but did not have TA.

A similar proportion of tendons underwent development (16.6%) and resolution (11.2%) in TA and/or pain over the season. Normal tendons were more likely to undergo development in TA alone (21.5%) rather than develop TA and pain (4.0%) (fig 1). Tendons with TA and pain were more likely to undergo resolution in TA (24.7%) rather than experience resolution in TA and pain (1.3%) (fig 1).

More than two thirds of the tendons with TA and pain at the beginning of the season were still affected by this injury at the end of the season. Of these, there was almost no change in the mean (SD) intensity of pain from the beginning (35.75 (23.71)) to the end (32.50 (22.69)) of the season ($t_{70} = 0.59$, $p = 0.55$). There was no difference between the sexes in the frequency of tendons that developed TA with or without pain over the season ($\chi^2(1) = 0.68$, $p = 0.59$) (table 2).

DISCUSSION

It has been proposed that there is an ordinal relationship between the development of TA and pain in patellar tendon

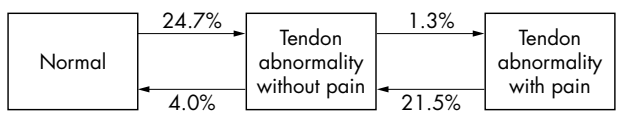

Figure 1 Ordinal relationship in the development and resolution of TA and pain.

What is already known on this topic?

- Previous longitudinal studies among athletes indicate that pain and tendon abnormality may develop or resolve over follow up periods that include the regular season and the pre-season and/or off-season[11–14]
- Additionally, the normal tendon is more likely to develop tendon abnormality rather than tendon abnormality with pain[11 13 14]

What this study adds

- This study demonstrated that even during the competitive season when activity is increased pain and tendon abnormality may develop or resolve
- This indicates that change in pain and tendon abnormality is not entirely dependent upon load
- This study also showed that pain is likely to resolve prior to tendon abnormality in tendons with both of these features

injury.[10] This is supported by this study (fig 1) and the literature,[11 13 14] in that normal tendons are more likely to develop TA rather than TA with pain. The current findings also indicate that pain may resolve prior to TA in tendons that contain both of these features (fig 1).

Despite players having an increased activity level during the season compared with the off season, a comparable proportion of tendons developed (16.6%) and underwent resolution (11.2%) in TA and pain. Additionally, tendons with TA with pain throughout the season did not demonstrate change in the intensity of pain over the season. Studies in the literature have reported similar findings in that 28–41% of tendons with TA at baseline were normal after follow up and 12–30% had developed pain.[11–14] Taken together with the current findings, resolution and development of TA and pain over time may not be entirely dependent on activity level.

This study demonstrated that TA with pain may resolve over a volleyball season. Only one previous study investigated tendons with TA with pain over time, and found that they did not change over the average follow up period of 18 months.[12] The current finding demonstrates that tendons with abnormality and pain may improve even when load is increased. Identifying the characteristics that identify the tendons with abnormality and pain that will respond favourably to load over the season may assist clinicians in providing advice to injured volleyball players.

The findings of this study question the factors that govern development and resolution of pain and/or TA over time. Tendon load may stimulate collagen synthesis and result in resolution of TA among some athletes. This is shown by studies using imaging on abnormal Achilles tendons that demonstrate a normalised imaging appearance after eccentric strengthening, which involves tendon load.[22] However, load may lead to tendon pathology[4] and stimulate pain mechanisms[23] in other athletes. The differential response of tendons to load is probably controlled by a complex interaction of many factors.

Sex is unlikely to be one of the factors that influences change in TA and pain over a volleyball season. In contrast to the findings of Cook *et al*[14] in adolescent basketball players, we found that men were not more likely to develop TA during the season than women.

In conclusion, this study demonstrates that over the season when players perform greater activity than at other times during the year, the proportion of tendons that developed and experienced resolution in TA and/or pain was comparable. Change in the status of TA and pain, and change in the intensity of pain over a season may not be dependent upon activity level or sex.

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Competing interests: none

REFERENCES

1 **Puddu G**, Cipolla M, Selvanetti A, *et al*. Patellar tendinopathies. *J Sports Traumatol Relat Res* 1999;**21**:41–8.
2 **Laforgia R**, Capocasale N, Saracino N, *et al*. A clinical and ultrasonographic study of jumper's knee and the achilles tendon in volleyball players. *J Sports Traumatol Relat Res* 1992;**14**:127–38.
3 **Lian O**, Holen KJ, Engebretson L, *et al*. Relationship between symptoms of jumper's knee and the ultrasound characteristics of the patellar tendon among high level male volleyball players. *Scand J Med Sci Sports* 1996;**6**:291–6.
4 **Kjaer M**. Role of Extracellulor matrix in adaptation of tendon and skeletal muscle to mechanical loading. *Physiol Rev* 2004;**84**:649–98.
5 **Alfredson H**, Forsgren S, Thorsen K, *et al*. In vivo microdialysis and immunohistochemical analysis of tendon tissue demonstrated high amounts of free glutamate and glutamate NMDAR1 receptors, but no signs of inflammation, in Jumper's knee. *J Orthop Res* 2001;**19**:881–6.
6 **Hart DA**, Frank CB, Bray RC. Inflammatory processes in repetitive motion and overuse syndromes: potential role of neurogenic mechanisms in tendons and ligaments. In: Gordon SL, Blair SJ, Fine LJ, eds. *Pathophysiology: connective tissue*. Park Ridge, IL: American Academy of Orthopaedic Surgeons, 1995:247–62.
7 **Gaida J**, Cook J, Bass S, *et al*. Are unilateral and bilateral patellar tendinopathy distinguished by differences in anthropometry, body composition, or muscle strength in elite female basketball players? *Br J Sports Med* 2004;**38**:581–5.
8 **Lian O**, Engebretsen L, Ovrebo RV, *et al*. Characteristics of the leg extensors in male volleyball players with jumper's knee. *Am J Sports Med* 1996;**24**:380–5.
9 **Ferretti A**. Epidemiology of jumper's knee. *Sports Med* 1986;**3**:289–95.
10 **Leadbetter W**. Cell matrix response in tendon injury. *Clin Sports Med* 1992;**11**:533–78.
11 **Fredberg U**, Bolvig L. Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and Achilles tendons of elite soccer players. *Am J Sports Med* 2002;**30**:488–91.
12 **Khan KM**, Cook JL, Kiss ZS, *et al*. Patellar tendon ultrasonography and jumper's knee in elite female basketball players: a longitudinal study. *Clin J Sports Med* 1997;**7**:199–206.
13 **Cook JL**, Khan KM, Kiss ZS, *et al*. Asymptomatic hypoechoic regions on patellar tendon ultrasound: A 4-year clinical and ultrasound followup of 46 tendons. *Scand J Med Sci Sports* 2001;**11**:1–7.
14 **Cook JL**, Khan KM, Zoltan ZS, *et al*. Prospective imaging study of asymptomatic patellar tendinopathy in elite junior basketball players. *J Ultrasound Med* 2000;**19**:473–9.
15 **Gabbe BJ**, Finch CF, Bennell KL, *et al*. How valid is a self reported 12 month sports injury history? *Br J Sports Med* 2003;**37**:545–7.
16 **Read JW**, Peduto AJ. Tendon imaging. *Sports Med Arthrosc Rev* 2000;**8**:32–35.
17 **Purdam C**, Cook J, Hopper D, *et al*. Discriminative ability of functional loading tests for adolescent jumper's knee. *Phys Ther Sport* 2003;**4**:1–7.
18 **Cook JL**, Khan KM, Kiss ZS, *et al*. Patellar tendinopathy in junior basketball players: a controlled clinical and ultrasonographic study of 268 tendons in players aged 14–18 years. *Scand J Med Sci Sports* 2000;**10**:216–20.
19 **Cook J**, Khan K, Kiss S, *et al*. Reproducibility and clinical utility of tendon palpation to detect patellar tendinopathy in young basketball players. *Br J Sports Med* 2001;**35**:65–9.
20 **Borgan O**. Estimation of covariate-dependent Markov transition probabilities from nested case-control data. *Stat Methods Med Res* 2003;**11**:183–202.
21 **Alfredson H**, Pietila T, Jonsson P, *et al*. Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. *Am J Sports Med* 1998;**26**:360–6.
22 **Ohberg L**, Lorentzon R, Alfredson H. Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow-up. *Br J Sports Med* 2004;**38**:8–11.
23 **Khan K**, Cook J. Overuse tendon injuries: Where does the pain come from? *Sports Med Arthrosc Rev* 2000;**8**:17–31.