Epidemiology of Patellar Tendinopathy in Elite Male Soccer Players

Martin Hägglund, Johannes Zwerver and Jan Ekstrand

Original Publication:

Martin Hägglund, Johannes Zwerver and Jan Ekstrand, Epidemiology of Patellar Tendinopathy in Elite Male Soccer Players, 2011, American Journal of Sports Medicine, (39), 9, 1906-1911.
http://dx.doi.org/10.1177/0363546511408877

Epidemiology of patellar tendinopathy in elite male soccer players

Martin Hägglund,* PT, PhD, Johannes Zwerver,† MD, PhD, Jan Ekstrand,‡ MD, PhD

* Department of Medical and Health Sciences, Division of Physiotherapy, Linköping University, Sweden

† Center for Sports Medicine, University Center for Sport, Exercise and Health, University Medical Center Groningen, University of Groningen, The Netherlands

‡ Department of Medical and Health Sciences, Division of Health and Society, Linköping University, Sweden

Corresponding author

Martin Hägglund

Department of Medical and Health Sciences, Division of Physiotherapy, Linköping University, SE-581 83 Linköping, Sweden

ACKNOWLEDGEMENTS

The participating clubs with all their players, coaching staff and medical staff are gratefully acknowledged. This study was supported by grants from the Union of European Football Associations and the Swedish Centre for Research in Sports.

Title

Epidemiology of patellar tendinopathy in elite male soccer players

Abstract

Background: Patellar **tendinopathy** is common among athletes in jumping sports and in sports with prolonged repetitive stress of the knee extensor apparatus. The epidemiology in soccer is not well described.

Purpose: To study the epidemiology of patellar **tendinopathy** in elite male soccer players and evaluate potential risk factors.

Study Design: Prospective cohort study

Methods: 51 European elite soccer clubs (2,229 players) from three different cohorts, Swedish First League cohort (SWE) and UEFA Champions League cohort (UCL), both playing on natural grass, and Artifical Turf cohort (ART) playing on third generation artificial turfs, were followed between 2001 and 2009. Individual player exposure in training and matches and time-loss injuries were recorded.

Results: In total, 137 patellar tendinopathies were recorded, comprising 1.5% of all injuries and corresponding to an incidence of 0.12 injuries/1000 hours. Each season, 2.4% of players were affected, with most injuries (**61**%) resulting in absence up to one week or less. **Twenty** per-cent of **tendinopathies** were recurrent complaints. No significant difference in season prevalence (**OR 0.93, 95% CI 0.60-1.44, p=0.74**) or incidence (**RR 1.20, 95% CI 0.82-1.75, p=0.36**) was observed between teams playing on artificial turf and natural grass respectively. **Multivariate logistic regression showed that a high total exposure hours (OR 1.02 per 10 hour increase; 95% CI 1.00-1.04, p=0.033) was a significant risk factor for patellar tendinopathy, and increased body mass was borderline significant (OR 1.15 per 5 kg increase; 95% CI 1.00-1.33, p=0.055). In addition, two acute partial tendon ruptures were recorded, but no total rupture.**

Conclusions: Although mainly mild in nature, patellar **tendinopathy** is a fairly common condition in elite soccer and the recurrence rate is high. Exposure to artificial turf did not

increase the prevalence or incidence of injury. High total amount of exposure was identified as a risk factor for patellar **tendinopathy**.

Key terms: Patellar tendinopathy – tendinosis – jumper's knee – football – artificial turf

What is known about the subject: Patellar tendinopathy (PT) is common in jumping sports and in sports with prolonged repetitive stress of the knee extensor apparatus, such as soccer**.** The epidemiology of PT in soccer is not well described, and the existing studies are limited by small samples. The evidence is limited regarding risk factors for PT in sports, with many conflicting results in the literature. In soccer, only few potential risk factors have been evaluated and data are available mainly from cross-sectional studies.

What this study adds to the existing knowledge: This was the first well sized prospective cohort study describing the epidemiology and risk factors for PT in soccer. The results concur with previous studies from other sports showing that a high overall exposure is a risk factor for PT, and increased body mass was borderline significant. In addition, incidence of PT was high during the pre-season when training load is increased, suggesting a link between tendon load and time-loss due to PT in soccer players. Exposure to soccer play on artificial turf was not associated with an increased risk of PT.

INTRODUCTION

Patellar tendinopathy **(PT)** is a common condition among athletes characterized by gradually progressive activity-related anterior knee pain and focal patellar tenderness (**29**). Symptoms are often serious leading to recurrent or long-standing impairment of athletic performance (20). Currently, there is no consensus on what is the most appropriate treatment of **PT** and treatment results are often disappointing (3,**26**). Patellar tendinopathy can thus have a major impact on the career of many athletes and for some it is even the reason to end their career prematurely (18).

Historically, it has often been referred to as jumper's knee because the prevalence is especially high in jumping sports. Lian et al. reported a current prevalence of 45 % in elite volleyball and 32 % in elite basketball players (20). However, also in other sports like soccer a prolonged repetitive stress of the knee extensor apparatus can lead to this overuse tendinopathy of the patellar tendon (17,20). Its etiology has not been elucidated completely so far but seems to be multifactorial. Evidence is limited regarding risk factors for **PT** with conflicting results in the literature. Some of the suggested intrinsic risk factors are male gender (20), high stature (20), high body mass (4,20,**22**,**23**), and reduced ankle dorsiflexion (**24**) while extrinsic factors include increased training frequency (4,7,11), high frequency of weight and jump training (20,**22**) and, in volleyball, playing on hard surfaces (1,7).

Soccer, one of the most popular sports with about 260 million players worldwide, causes a large amount of acute and chronic injuries in both male and female players of every age and at all playing levels (16). Up to now most attention in soccer related medical research has been paid to the epidemiology, prevention and clinical management of acute injuries such as knee, ankle and hamstring injuries, conditions which give rise to significant morbidity in soccer

players and that can also result in high medical costs and financial burden for professional soccer teams (6). Even though **PT** might also negatively influence the athletic performance and career of soccer players, surprisingly few research papers have been published about patellar tendon injuries involving soccer players (8,9,19,20). Furthermore, the few studies that have been published are limited by small samples.

Therefore, the aim of this study was to describe the epidemiology of **PT** in a large population of elite male soccer players and to identify potential risk factors.

MATERIALS AND METHODS

Participants and study cohorts

Data was derived from three prospective cohort studies of European elite men's soccer carried out between 2001 and 2009. The study cohorts comprised in total 51 teams (2,299 players) followed over a varying number of seasons; the *UEFA (Union of European Football Associations) Champions League cohort (UCL)* (6,**30**) included 24 European professional teams from 10 countries followed between July 2001 and June 2009 (mean 4.3 seasons or 45.3 months participation per team) and consisted of 1210 players; the *Swedish First League cohort (SWE)* (13,14) comprised 15 Swedish top division teams followed over three seasons (January to November) 2001, 2002 and 2005 (mean 2.3 seasons or 23.3 months/team) with 508 players; and the *Artifical Turf cohort (ART)* (5) included 15 European elite teams (top two domestic divisions) from eight countries followed between February 2003 and December 2009 (mean 3.3 seasons or 30.3 months/team) with 661 players. All contracted players in the first teams were invited to participate in the study. Players who left the team during the season, e.g. due to transfer, were included during their time in the team. Anthropometrics and exposure data for the three cohorts are shown in Table 1.

Teams were followed during the full soccer season, including pre-season and competitive season. Teams in the UCL and SWE cohorts trained mainly on natural grass and played their home matches on natural grass. Teams in the ART cohort all played on third generation artificial turfs at their home grounds and also trained mainly on artificial turf, while away matches were played mainly on natural grass. Three teams were initially included in the SWE cohort (seasons 2001 and 2002) and then entered the ART cohort due to a change from natural grass to artificial turf playing surface. **Exposure and injury data from these three**

teams were included in the SWE cohort during the 2001 and 2002 seasons whilst playing on natural grass, and then included in the ART cohort from season 2003 after the change of playing surface.

Table 1 near here

Data collection and study definitions

The study design followed the definitions and data collection procedures outlined in the consensus document (10) and by UEFA (12) for studies of soccer injuries. The validation of the injury and exposure reporting system and definitions has been described previously (12). To ensure high reliability of data registration all teams were provided with a study manual describing the definitions used and procedures to record data, including **explanatory** examples. In addition, all reports were checked each month by the study group and feedback sent to the teams in order to correct any missing or unclear data. The definitions applied in the study are shown in Table 2.

Player baseline data was collected once yearly, at the start of each season. Individual player participation in training and matches (minutes of exposure) was registered by the club contact person on a standard exposure form sent to the study group on a monthly basis. This included exposures with the first and second team, as well as any national team exposure, for all players. **The training content was not recorded**. The team medical staffs recorded **all time-loss** injuries on a standard injury form that was sent to the study group each month. The injury form provided information about the diagnosis, nature and circumstances of injury occurence. Injuries were categorised under four degrees of severity based on the number of days' absence. All injuries were followed until the final day of rehabilitation. **For the present**

study we included all recorded patellar tendon injuries, comprising both gradual onset patellar tendinopathies and acute onset patellar tendon partial ruptures. The diagnosis was based on the clinical examination by the team medical staff, and no specific diagnostic criteria were sent out in advance.

Table 2 near here

Risk factor evaluation

We collected information about potential intrinsic risk factors for all players when entering the study; age, stature, body mass and playing position (goalkeeper, defender, midfielder, forward). The extrinsic risk factors evaluated in the study were total exposure hours (hours of soccer training and match play), training/match exposure ratio (hours of training/hours of match play), team home surface (natural grass or artificial turf), and seasonal distribution (autumn to spring or spring to autumn season).

Statistical analyses

ANOVA was used for group comparisons of continuous normally distributed data, **the Mann-Whitney U-test or Wilcoxon signed rank test for continuous non-normally distributed data** and the χ^2 test for categorical data. Injury incidence was calculated as the number of injuries per 1,000 player hours, and compared between groups with rate ratios (RR) with 95 % confidence intervals (95 % CI), and significance tested using z-statistics. Season injury prevalence was calculated as the number of injured players during a season/total number of players in that season x 100, and was compared between groups with odds ratios (OR) and corresponding 95 % CI, and significance tested with z-statistics. The risk factor analysis **was made with the player as unit for analysis**, and odds ratios (OR) with 95 % CI are presented

for all variables based on univariate logistic regression. For the multivariate analysis we included all variables in a backward stepwise logistic regression, and variables with $p<0.20$ were included in the final model. The significance level was set at $p<0.05$ for all analyses.

The study design underwent an ethical review and was approved by the UEFA Football Development Division and the UEFA Medical Committee.

RESULTS

In total, 139 patellar tendon injuries were registered; 137 of which were gradual onset tendinopathies (PT) and two were acute onset partial tendon tears. The two acute partial tears affected one player in the UCL and ART cohorts respectively, and due to their different aetiology (acute onset) these two injuries are not included in the following results section. No total patellar tendon rupture was recorded.

Nature and severity of patellar tendinopathies

Four injuries affected the distal patellar tendon, and the remaining 133 were proximal. Fifty-**five** injuries (40 %) affected the dominant leg (preferred shooting leg), 66 injuries (**48** %) the non-dominant leg (p=**0.36** vs dominant leg), 4 injuries (3 %) affected both knees, and for **12** injuries (9 %) the leg dominance was unknown.

PT constituted 1.5 % of the total number of injuries registered in the three cohorts, and caused 1.4 % of the total injury absence in the clubs (Table 3). The majority of injuries resulted in absence less than one week (**61** %), while **10** % were severe, causing absence more than 4 weeks from training and match play. **Two** of the severe injuries were surgically treated. **The median absence due to PT was 5 days, with 75 % of players returning within 12 days**. One in five injuries was a recurrent complaint, with no difference in absence between recurrent and index injuries **(median 5 days for both, p=0.58)**. No inter-cohort differences were observed for recurrence rates (p=**0.29**), injury severity (**p=0.90**) or **median** days absence per injury (p=**0.71**).

Table 3 near here

Season prevalence and incidence

Each season, 2.4 % of players (season prevalence) missed training or match playing time due to **PT**, with an incidence of 0.12 injuries/1,000 hours of total exposure (Table 3). No significant difference in season prevalence or incidence of **PT** was observed between teams playing on artificial turf and those playing on natural grass; prevalence **2.25** % vs 2.42 % (**OR 0.93, 95 % CI 0.60-1.44, p=0.74**); incidence **0.13** vs 0.11/1,000 hours (**RR 1.20, 95 % CI 0.82-1.75, p=0.36**).

The distribution of **PT** over the season is shown in Figure 1. For teams following an spring-to-autumn season the incidence of PT was increased during the pre-season (January to March) compared to the competitive season (April to November) (0.18 vs 0.10/1000 hours, RR 1.86; 95% CI 1.08-3.20, p=0.026). The incidence for teams following an autumn-to-spring season peaked in July, October and April.

Figure 1 near here

Risk factors for PT

Results of the univariate logistic regression showed that total exposure hours during a season was the only variable significantly associated with PT (Table 4). In the backward stepwise multivariate logistic regression three variables were included in the final model; total exposure hours **(OR 1.02 per 10 hour increase; 95 % CI 1.00-1.04, p=0.033), body weight (OR 1.15 per 5 kg increase; 95 % CI 1.00-1.33, p=0.055), and age (OR 0.97; 95 % CI 0.93-1.01, p=0.17), while all other variables had p>0.20**.

DISCUSSION

The main finding of this study was that during the season 2.4 % of all elite soccer players missed training or match playing time due to PT. The absence because of PT was rather short, in the majority of cases less than one week, but the recurrence rate was high. There was no difference in incidence or prevalence of PT from playing on artificial turf or natural grass. High total amount of exposure was identified as a risk factor for PT. The strength of the study is the prospective design and that a large population of elite athletes was followed using the same methodology that complied with international guidelines (10,12).

Prevalence and incidence of PT

Few studies have reported on the epidemiology of PT in soccer. Lian et al. described a high, 23 %, overall prevalence (present and previous symptoms) of **PT** in Norwegian elite male soccer players, with a point prevalence of 13 % (20). However, these data are difficult to compare with our season prevalence since non time-loss injuries were included. Studies from Danish elite male soccer show that 7 % of players (3.1 to 7 % of patellar tendons) developed symptomatic **PT** during a season (8,9). Interestingly, as many as 6 % of players (3% of patellar tendons) reported time loss due to **PT** (9), indicating that over the season a majority of players with PT developed symptoms severe enough to limit performance and leading to missed training or match exposure. The season prevalence found in the present study (2.3-2.6 %) was less than half of that reported previously, but it is not known whether this reflects a true difference in injury prevalence or differences in study methodology, reporting thresholds or varying treatment regimes (i.e. to let players with symptoms carry on playing or take them out of training). We found no difference in incidence or prevalence of PT between the three different cohorts in our study, representing the highest professional European level (UCL),

and high European elite level (ART, SWE). Noteworthy is that only two acute onset partial ruptures were identified in this study, **and no complete rupture**, indicating that **these are rare conditions** in elite soccer. **Tendon rupture is considered the final stage of PT (21) and one could speculate that by early identification and treatment of the condition, and by a reduction of tendon load (e.g. alternative training programmes) during symptomatic periods, tendon ruptures were avoided in these elite soccer players.**

High recurrence rate

The high recurrence rate found in this study (12-27 %) reflects the chronic and recurrent character of this troublesome condition, and corresponds with previous studies of male elite soccer (21 %) (9). After a short period of rest, load reduction and treatment athletes become asymptomatic and may restart competing until another period of symptoms occurs. From studies in volleyball players it is clear that pain and ultrasonographic abnormalities can vary over the season (**25**), being indicative of players having recurrent complaints. There is, unfortunately, little evidence on how to prevent these recurrent episodes of PT in athletes. Eccentric training, a cornerstone in the conservative treatment of chronic **PT** (**26,28**), has not shown similarly good results for prevention (9). However, correction of intrinsic and extrinsic risk factors should be an important part in prevention. For instance, an adapted training programme may be advised to athletes with a previous history of PT during parts of the season involving increased load, e.g. during the pre-season preparation or during intense parts of the competitive season, in order to prevent recurrent complaints.

Risk factors for PT

In our group of elite male soccer players, a high total amount of exposure was associated with an increased risk of PT. This is in line with previous cross-sectional studies from volleyball

(7), basketball (11) and various sports (4) where an association between training load/hours of sports participation and prevalence of **PT** was observed. The finding is probably indicative of the condition's overuse nature with prolonged repetitive stress of the patellar tendon. For northern European clubs, following a spring to autumn season, an increase in incidence of PT was observed during the pre-season period when training load is high, thus possibly supporting an association between tendon load and development of symptomatic PT. In contrast, Lian et al. reported no difference in overall training amount, amount of sport-specific training, weight training, jump training or other types of training between soccer players with current or previous complaints of **PT** and those without in their cross-sectional study (20).

Of the **potential anthropometric risk factors** evaluated in the present study, only increased body mass was **borderline** significant. **Increased body mass has been identified as a risk factor in** previous studies in volleyball players (4,20,**22,23**) and may be due to increased forces acting on the patellar tendon with an increased body mass. Stature was not associated with development of PT in our study, which is in agreement with most studies (4,11,**22,23**), while Lian et al. reported, from their cross-sectional study, that increased stature was associated with the risk of **PT** in soccer players (20). Similar to previous studies (4,11,20,**22**) age was not associated with the risk of PT in our group of elite soccer players. Furthermore, we found no association between leg dominance or playing position and development of PT.

We found no influence on injury rates from playing surface, whether mainly played on artificial turf or natural grass. Previous reports from the same cohort of elite clubs playing on artificial turf showed that the incidence of acute injuries is also comparable between surfaces (5). Ferretti et al. showed, in a study of volleyball players, that the prevalence of PT increased with a harder playing surface (7) and another study (1) reported a lower prevalence of PT in

beach volleyball compared to previous studies from indoor volleyball, indicating that ground hardness may be correlated with PT. The elite soccer clubs in the ART cohort in our study all played on home grounds with third generation artificial turfs, developed to resemble natural grass and using sand and rubber granules, and sometimes a shock absorbing rubber pad, to reduce ground hardness. Considering that the incidence of PT among northern European teams in our study was high during pre-season, a period with poorer weather and cold temperatures, a possible association between climate conditions, ground hardness and injury rates in soccer should be evaluated further.

Methodological considerations

First, a limitation of the study is related to the registration of injuries. No specific set diagnostic criteria for a patellar tendon injury were used. We followed the football consensus proposal for general definitions, and all patellar tendon injuries leading to time loss from training or match play were reported by the team medical staff. Furthermore, we did not collect specific data on the severity of patellar tendinopathies (e.g. VISA-P score (27)) other than time loss due to the injury. No imaging data were obtained from the injured football players either. Therefore, only symptomatic **PT** and acute onset patellar tendon partial ruptures, diagnosed on the clinical experience of the team medical staff, were included. On the other hand, the correlation between imaging (MRI or ultrasound) and clinical findings is often low (9,25) and clinical examination will identify players with symptomatic patellar tendon injury during soccer training and/or match play. Finally, with the current time loss definition used it should be recognised that the injuries captured in our surveillance study probably represents the tip of the iceberg and our data might underestimate the magnitude and impact of this chronic overuse injury (2). It is well known that many athletes with PT may keep on participating in training and matches despite having some pain. **However, the**

definition was chosen for the general injury surveillance study to capture injuries with substantial effect on players' health and performance as well as on the performance of the team (12).

Second, another limitation refers to the registration of training exposures. We only registered collective team training, and not any other individual training (e.g. strength and conditioning training) that players performed as a part of their daily routines in the club, or outside of the club. Therefore, the total training load of players is not known. In order to control for such factors it has been recommended that individual activities should be recorded also in team sports like soccer (15). Furthermore, the intensity and type of training performed was not registered, and this is another limiting factor since it has been shown that high volumes of jump training and eccentric load may increase the risk of PT (20,**22**). However, even though this may slightly interfere with inter-sport comparisons, it is unlikely that the type of training differs substantially between the different cohorts of elite male football players included in this study **and that this would affect our evaluated risk factors** (**e.g. comparison between teams playing on artificial turf and natural grass**).

CONCLUSION

Patellar tendinopathy is a rather common condition in elite soccer players, with a high recurrence rate. High overall exposure during a season was a risk factor for developing PT. Furthermore, an increased incidence of PT was observed during the pre-season period when training load is high. These findings indicate a link between patellar tendon load and injury occurrence, even though results should be confirmed in future studies. More high-quality studies on risk factors for PT in professional as well as in female, amateur and youth soccer are needed to generate preventive strategies.

REFERENCES

1. Bahr R, Reeser JC. Injuries among world-class professional beach volleyball players. The Fédération Internationale de Volleyball beach volleyball injury study. *Am J Sports Med* 2003;31:119-25.
2. Bahr R. No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med* 2009;43:966-72.
3. Cook JL, Khan KM. What is the most appropriate treatment for patellar tendinopathy? *Br J Sports Med* 2001;35:291-4.
4. Crossley KM, Thancanamootoo K, Metcalf BR, Cook JL, Purdam CR, Warden SJ. Clinical features of patellar tendinopathy and their implications for rehabilitation. *J Orthop Res* 2007;25:1164-75.
5. Ekstrand J, Hägglund M, Fuller CW. Comparison of injuries sustained on artificial turf and grass by male and female elite football players. *Scand J Med Sci Sports* 2010, [Epub ahead of print] PMID: 20456680
6. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury pattern in professional football - the UEFA injury study. *Br J Sports Med* 2010, [Epub ahead of print] PMID: 19553225
7. Ferretti A, Puddu G, Mariani PP, et al. Jumper's knee: an epidemiological study of volleyball players. *Physician Sportsmed* 1984;12:97-106.
8. Fredberg U, Bolvig L. Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and Achilles tendons of elite soccer players. A longitudinal study. *Am J Sports Med* 2002;30:488-91.
9. Fredberg U, Bolvig L, Andersen NT. Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in achilles and patellar tendons. The Danish super league study. *Am J Sports Med* 2008;36:451-60.

10. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med* 2006;40-3:193-201.
11. Gaida JE, Cook JL, Bass SL, Austen S, Kiss ZS. 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.
12. Hägglund M, Waldén M, Bahr R, Ekstrand J. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med* 2005;39:340-6.
13. Hägglund M, Waldén M, Ekstrand J. Injuries among male and female elite football players. *Scand J Med Sci Sports* 2009,19: 819-27.
14. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football - a prospective study over two consecutive seasons. *Br J Sports Med* 2006;40:767-72.
15. Hägglund M, Waldén M, Til L, Pruna R. The importance of epidemiological research in sports medicine. *APUNTS Medicina de l'Esport* 2010 *DOI:10.1016/j.apunts.2010.02.006*
16. Junge A, Dvorak J. Soccer injuries. A review on incidence and prevention. *Sports Med* 2004;34:929-38.
17. Kannus P. Etiology and patophysiology of chronic tendon disorders in sports. *Scand J Med Sci Sports* 1997;7:78-85.
18. Kettunen JA, Kvist M, Alanen E, Kujala UM. Long-term prognosis for jumper's knee in male athletes. A prospective follow-up study. *Am J Sports Med* 2002;30:689-92.
19. Kraemer R, Knobloch K. A soccer-specific balance training program for hamstring muscle and patellar and Achilles tendon injuries. An intervention study in premier league female soccer. *Am J Sports Med* 2009;37:1384-93.

20. Lian Ø, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports. A cross-sectional study. *Am J Sports Med* 2005;33:559-67.

21. Lian Ø, Holen KJ, Engebretsen L, Bahr R. 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.

22. Lian Ø, Refsnes PE, Engebretsen L, Bahr R. Performance characteristics of volleyball players with patellar tendinopathy. *Am J Sports Med* 2003;31:408-13.

23. Malliaras P, Cook JL, Kent P. Anthropometric risk factors for patellar tendon injury among volleyball players. *Br J Sports Med* 2007;41:259-63.

24. Malliaras P, Cook JL, Kent P. Reduced ankle dorsiflexion range may increase the risk for patellar tendon injury among volleyball players. *J Sci Med Sport* 2006;9:304-9.

25. Malliaras P, Cook J, Ptasznik R, Thomas S. Prospective study of change in patellar tendon abnormality on imaging and pain over a volleyball season. *Br J Sports Med* 2006;40:272-74.

26. Peers K, Lysens R. Patellar tendinopathy in athletes. Current diagnostic and therapeutic recommendations. *Sports Med* 2005;35:71-87.

27. Visentini PJ, Khan KM, Cook JL, Kiss ZS, Harcourt PR, Wark JD. The VISA score: an index of severity of symptoms in patients with jumper's knee (patellar tendinosis). Victorian Institute of Sport Tendon Study Group. *J Sci Med Sport* 1998;1:22-8.

28. Visnes H, Bahr R. The evolution of eccentric training as treatment for patellar tendinopathy (jumper's knee): a critical review of exercise programmes. *Br J Sports Med* 2007;41:217-23.

29. Warden SJ, Brukner P. Patellar tendinopathy. *Clin Sports Med* 2003;22:743-59

30. Waldén M, Hägglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001-2002 season. *Br J Sports Med* 2005;39:542-6.

31. **Table 1. Player anthropometrics and exposures in three cohorts of elite male soccer players.**

	UCL[1]	SWE[1]	ART[1]
No. of teams (team seasons[2])	24 (104)	15 (35)	15 (49)
No. of players (player seasons[2])	1210 (2686)	508 (774)	661 (1198)
Player anthropometrics[3]			
Age (years)	25.7 ± 4.5	24.8 ± 4.7	25.0 ± 4.8
Height (cm)	181.7 ± 6.4	182.5 ± 5.7	181.8 ± 6.2
Weight (kg)	78.0 ± 7.0	79.0 ± 6.1	78.1 ± 6.9
Player exposures (per season)[3]			
No. of training sessions	161 ± 55	184 ± 50	144 ± 69
Training hours	210 ± 73	262 ± 71	193 ± 89
No. of matches	33 ± 17	30 ± 12	26 ± 15
Match hours	41 ± 24	38 ± 17	32 ± 20
No. of total activities	195 ± 67	214 ± 59	170 ± 80
Total training + match hours	250 ± 87	300 ± 83	225 ± 104

[1] UEFA Champions League (UCL), Swedish First League (SWE), Artificial Turf (ART)

[2] One team or player participating in one season equals one team and one player season respectively

[3] Values are mean ± standard deviation

Table 2. Study definitions.

Training session	Team training that involved physical activity under the supervision of the coaching staff.
Match	Competitive or friendly match against another team.
Injury	Injury resulting from playing football and leading to a player being unable to fully participate in future training or match play (i.e. time-loss injury).
Patellar tendon injury	Overuse (**tendinopathy**) or traumatic distraction injury (**partial or total tear**) located to the patellar tendon leading to a player being unable to fully participate in training or match play.
Rehabilitation	A player was considered injured until team medical staff allowed full participation in training and availability for match selection.
Re-injury	Injury of the same type and at the same site as an index injury occurring no more than two months after a player's return to full participation from the index injury.
Minimal injury	Injury causing absence of 1–3 days from training and match play.
Mild injury	Injury causing absence of 4–7 days from training and match play.
Moderate injury	Injury causing absence of 8–28 days from training and match play.
Severe injury	Injury causing absence of over 28 days from training and match play.
Traumatic injury	Injury with sudden onset and known cause.
Overuse injury	Injury with insidious onset and no known trauma.
Season prevalence	Number of injured players in a season/total number of players in the same season × 100
Injury incidence	Number of injuries per 1,000 player hours [(Σ injuries/Σ exposure hours) × 1,000].

Table 3. Nature, prevalence and incidence of patellar tendinopathy[1].

	Total	UCL[2]	SWE[2]	ART[2]
No of patellar **tendinopathies**	137	76	25	36
Percentage of total no of injuries	1.48%	1.43%	1.43%	1.62%
Injury severity				
Minimal (1-3 days)	57 (42%)	31 (41%)	12 (48%)	14 (39%)
Mild (4-7 days)	27 (20%)	16 (21%)	3 (12%)	8 (22%)
Moderate (8-28 days)	39 (28%)	22 (29%)	8 (32%)	9 (25%)
Severe (>28 days)	14 (10%)	7 (9%)	2 (8%)	5 (14%)
Days absence/injury[3]	5 (2;12)	4.5 (3;12)	4 (2;9.5)	6 (2;15)
Days absence/player/season	0.44	0.43	0.31	0.53
Percentage of total injury absence	1.29%	1.17%	0.92%	1.96%
Season prevalence[4]	2.38%	2.37%	2.58%	2.33%
Injury incidence[5]	0.12 (0.10-0.14)	0.11 (0.09-0.14)	0.11 (0.07-0.16)	0.13 (0.10-0.19)
Injury burden[6]	1.74	1.72	1.04	2.37
Re-injuries	27 (20%)	14 (18%)	3 (12%)	10 (28%)

[1] **Two acute onset patellar tendon partial ruptures (one in the UCL and ART cohorts respectively) are not included in the table**

[2] UEFA Champions League (UCL), Swedish First League (SWE), Artificial Turf (ART)

[3] **Median (25%;75% quartiles)**

[4] Season prevalence expressed as number of players with an injury in a season/total no of players that season × 100

[5] Injury incidence expressed as number of injuries/1000 hours of total exposure (95% CI)

[6] Injury burden expressed as number of days absence/1000 hours of total exposure

Table 4. Results of univariate logistic regression for potential risk factors for patellar tendinopathy.

Risk factor	Odds ratio	95% CI	P-value
Age	0.98	0.94-1.02	0.41
Stature (5 cm interval)	1.09	0.94-1.27	0.25
Body mass (5 kg interval)	1.13	0.98-1.30	0.083
Total exposure (10 hour interval)	1.02	1.00-1.04	0.032
Training / match exposure ratio	1.00	0.99-1.02	0.70
Team home surface			
Natural grass[1]	1.00		
Artificial turf	1.08	0.70-1.67	0.74
Seasonal distribution			
Autumn-spring season[1]	1.00		
Spring-autum season	0.96	0.65-1.43	0.85
Playing position			
Goalkeeper[1]	1.00		
Defender	1.04	0.52-2.08	0.91
Midfielder	0.89	0.46-1.75	0.74
Forward	0.89	0.43-1.81	0.74

[1] Reference group

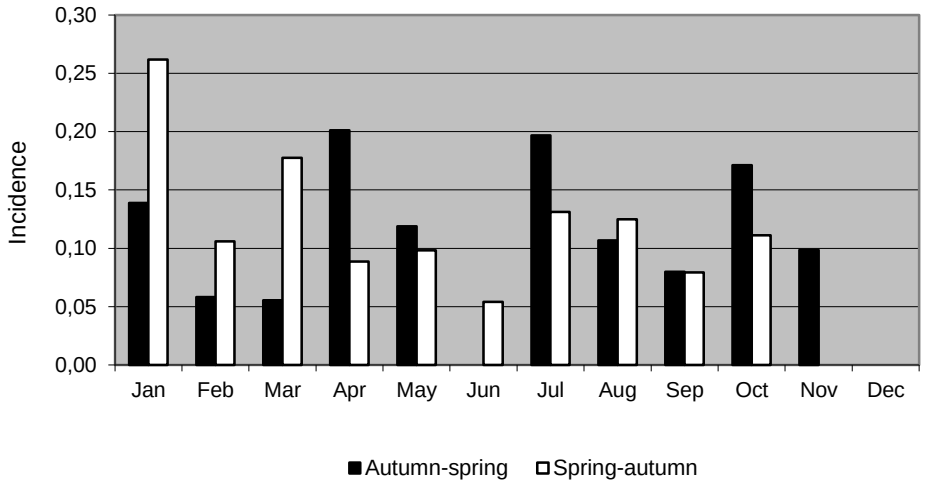

Figure 1. Incidence (injuries/1000 hours) of patellar tendinopathy over the season for teams following an autumn-to-spring season (July-May, black bars) and a spring-to-autumn season (January-November, white bars), respectively.