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Epidemiology and return to play following isolated syndesmotic injuries of the ankle: a prospective cohort study of 3677 male professional footballers in the UEFA Elite Club Injury Study

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Thank you for your comments. We believe that you've made some very valid points and have therefore in collaboration with our statistical advisor changed the statistical methods that we have used to analyse this material in the updated manuscript in accordance with your comments.

Editor Remarks	Authors' Responses	Text Changes (marked yellow in the manuscript)
1. There are several outcomes in this paper. Poisson regression model is the choice for analysis of rate. Linear regression model with some appropriate transformation can be used for other outcomes including the annual changes in injury incidence, injury burden, and syndesmotic injury proportion.	We have now analysed the difference in injury rate between training and match play with Poisson regression. The results from this analysis are identical to our previous analysis but the description of the statistical method has changed in the revised manuscript.	Line 161 - 163 now reads: "Injury incidence in training and match play were calculated and rate ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset." Line 168 - 180 now reads: "Injury burden in training and match play were calculated and injury burden ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset. The annual changes in injury incidence, injury burden, and syndesmotic injury proportion (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) were analysed using linear regression. In these analyses injury incidence, injury burden and syndesmotic injury proportion was used as dependent variables in separate analyses, while season was used as the independent variable in all analyses. In

		addition, injury incidence, injury burden and syndesmotic injury proportion in match play were also analysed using linear regression with season included as the independent variable. Analyses of training injuries specifically were not performed since the number of injuries during training were few."
2. Unfortunately, this paper neither discusses the choice of confounders and model selection nor assesses the correctness of the model. Both issues are very important as observational studies are subject to confounding and correct model specification is a crucial assumption.	We agree that this is important when interpreting our results and have extended the discussion about possible confounders that we were not able to include in our analyses.	Line 322 – 323 now reads: "We were not able the capture data on possible confounders and these could therefore not be included in our analyses. First…" Line 329 – 330 now reads: "Fourth, we did not capture data on player medical history (i.e., previous syndesmotic or ankle ligament injury)."
3. The authors stated that "In these analyses, a log-transformation of the dependent variables injury incidence, injury burden and syndesmotic injury proportion was used in separate analyses", but they did not assess the normality and homogeneity of variance of residuals which are important assumptions for model-based inference. Moreover, log-transformation is not appropriate (variance stabilizing) for proportion.	Thank you. This is indeed also an important point. We have analysed the residuals for all included variables and found no reason to transform them. We therefore decided to analyse these variables with linear regression without log-transformation of the dependent variables in the revised manuscript. This has changed our results to some extent, but the main conclusions are the same.	Line 72 – 84 now reads: "The injury incidence during match play was 13 times higher compared to during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively. Out of the 1320 ankle ligament injuries registered during the 15 seasons 94 (7%) were diagnosed as isolated syndesmotic injuries. An annual increase in injury incidence was observed (R^2=0.495, b=0.003, 95% CI 0.001 to 0.004, p=0.003). However, no significant annual change of injury burden was observed (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520)." Line 83 – 84 now reads: "The incidence of

		isolated syndesmotic injuries in elite professional European football annually increased between 2001-16." Line 189 – 194 now reads: "The injury incidence during match play was 13 times higher compared to the incidence during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively (RR 12.63; 95% CI 8.12 to 19.65). A significant annual increase in isolated syndesmotic injury incidence in general (R^2=0.495, b=0.003, 95% CI 0.001 to 0.004, p=0.003) as well as in match play (R^2=0.354, b=0.013, 95% CI 0.002 to 0.023, p=0.019) was observed over the 15 seasons" Line 195- 198 now reads: "The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in syndesmotic injury incidence in general (R^2=0.822, b=0.003, 95% CI 0.002 to 0.004, p<0.001) as well as in match play (R^2=0.751, b=0.015, 95% CI 0.009 to 0.020, p<0.001)" Line 203 – 211 now reads: "An annual increase of the proportion of syndesmotic injuries (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) was observed (R^2=0.601, b=0.006, 95% CI 0.003 to

		0.009, p=0.001) (figure 2). The proportion of syndesmotic injuries during match play also increased annually (R^2=0.430, b=0.006, 95% CI 0.002 to 0.010, p=0.008). The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in the proportion of syndesmotic injuries in general (R^2=0.818, b=0.006, 95% CI 0.004 to 0.008, p<0.001) and in match play (R^2=0.758, b=0.006, 95% CI 0.004 to 0.009, p<0.001).” Line 238 – 243 now reads: “There were no significant annual changes in injury burden in general (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520) or in match play (R^2=0.003, b=0.060, 95% CI -0.598 to 0.718, p=0.847). Similarly, no annual change in general (R^2=0.059, b=0.028, 95% CI -0.043 to 0.099, p=0.405) or in match play (R^2=0.005, b=0.050, 95% CI -0.389 to 0.488, p=0.809) was shown when the two-season moving average of injury burden was analysed” Line 281 – 283 now reads: “Over the 15 seasons an annual increase in isolated syndesmotic injury incidence in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per 1.000 hours) was observed”

4. There are also some errors in the interpretation e.g., "A significant 7.5% annual increase in isolated syndesmotic injury incidence was observed (R2=0.525, b=0.075, 95% CI 0.032 to 0.117, p=0.002) over the 15 seasons" In fact, b=0.075 in a linear regression with an outcome on the log-scale does not simply translate to 0.075 increase in outcome per one unit increase in the explanatory variable season, because outcome is on the logarithmic scale, let alone to a 7.5% annual increase in outcome!	Once again a valid point. In the revised manuscript we have decided to not use log-transformed dependent variables.	Line 83 – 84 now reads: "The incidence of isolated syndesmotic injuries in elite professional European football annually increased between 2001-16." Line 161 - 163 now reads: "Injury incidence in training and match play were calculated and rate ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset." Line 281 – 283 now reads: "Over the 15 seasons an annual increase in isolated syndesmotic injury incidence in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per 1.000 hours) was observed"

Epidemiology and return to play following isolated syndesmotic injuries of the ankle: a prospective cohort study of 3677 male professional footballers in the UEFA Elite Club Injury Study

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Abstract

Aim

To determine the epidemiology of isolated syndesmotic injuries in professional football players.

Methods

Data from 15 consecutive seasons of European professional football between 2001 and 2016 contributed to the dataset of this study. Match-play and training data from a total of 3677 players from 61 teams across 17 countries have been included. Team medical staff recorded player exposure and time loss injuries. Injury incidence was defined as the number of injuries per 1000 player-hours. Injury burden was defined as number of days absence per 1000 player-hours. Seasonal trends for isolated syndesmotic injury incidence, isolated syndesmotic injury proportion of ankle ligament injuries, and isolated syndesmotic injury burden were analysed via linear regression.

Results

The isolated syndesmotic injury incidence was 0.05 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury incidence during match play was 13 times higher compared to during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively. Out of the 1320 ankle ligament injuries registered during the 15 seasons 94 (7%) were diagnosed as isolated syndesmotic injuries. An annual increase in injury incidence was observed (R^2=0.495,

b=0.003, 95% CI 0.001 to 0.004, p=0.003). However, no significant annual change of injury burden was observed (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520). 74% of the injuries were contact related and the mean (+/- SD) absence following an isolated syndesmotic injury was 39 (+/- 28) days.

Conclusions

The incidence of isolated syndesmotic injuries in elite professional European football ~~annually increased between 2001-16~~.

Key Words: syndesmosis, high ankle sprain, incidence, football, epidemiology

What are the new findings

- Injury incidence during match play has increased over the past 15 seasons
- Isolated syndesmotic injury in football is most commonly caused by tackling
- Average return to play after injury exceeds 5 weeks

How might it impact on clinical practice in the near future

- Our findings may assist in making football players, coaches, referees and the club medical staff aware of isolated syndesmotic injury and its consequences
- Our findings may contribute to the development of injury prevention strategies in football as they demonstrate that isolated syndesmotic injuries are most commonly caused by player-tackling

Introduction

Ankle syndesmosis injury may occur in many forms, commonly classified into isolated ankle syndesmosis injury or with an associated fibula fracture. An isolated injury may occur to any one of the three distinct ligaments (the anterior inferior tibiofibular ligament, the interosseous tibiofibular ligament, and the posterior inferior tibiofibular ligament),[1 2] but will most commonly involve the anterior inferior tibiofibular ligament.[3 4] The most common mechanisms of syndesmotic ligament injury are ankle external rotation and hyperdorsiflexion, causing the talus to rotate in the mortise and the fibula to rotate externally ~~and moving posteriorly and laterally~~, providing stress to the anterior inferior tibiofibular ligament.[3-5]

Isolated syndesmotic injuries occur more commonly in athletes than in the general population.[5-13] Certain sports are characterised by a higher proportion of ankle syndesmosis injuries; these include boot immobilised sports[5-8] such as skiing and ice-hockey, as well as collision sports such as American football, wrestling, and rugby.[9 10 12 14]

For football, however, epidemiological data on isolated syndesmotic injuries is limited. Mauntel et al.[15] studied isolated syndesmotic injuries in 25 sports during six seasons and described the incidence rate, injury mechanism, recurrence, and time to return to activity of non-professional football players. Due to differences in competition level, speed of the game, body shape of the players, and playing calendar it is expected that epidemiology and etiology of syndesmotic injuries differ between non-professional and professional players. A better understanding of how and when professional players incur these injuries may help the development of preventive strategies as well as

providing important data regarding expected return to play times.[16]

We aimed to determine the injury incidence and epidemiology of isolated syndesmotic injuries of the ankle in professional football players over a 15 year period. In addition, we assessed the time to return to competition following an injury.

Material and methods

This is a substudy of a long-term prospective cohort study evaluating men's professional football in Europe since 2001.[17] The current study includes data from 15 consecutive seasons of European professional football between 2001 and 2016. During the study period, a total of 3677 players from 61 teams representing 17 countries have been included (table 1).

Exposure and injury registration

All first team players in included teams were invited to participate in the study. Participation was voluntary and written informed consent was obtained at the time of study inclusion. At the beginning of every season, teams appointed a contact person within each respective medical team to be responsible for collecting data and communicating with the study group. During the study period, all individual player exposure during supervised training sessions and matches was recorded on standard attendance records. In addition, all time loss injuries that occurred were registered on standard injury cards containing information about type of injury and circumstances of the injury occasion (ie. injury mechanism, affected side, time of injury, re-injury)(table 2). Each month, the appointed contact person reported the attendance records and injury cards to the study group. All injuries were given a diagnostic code by the study group in accordance with the Orchard Sports Injury Classification System (OSICS) 2.0.[18] OSICS 2.0 codes were used to identify isolated ankle syndesmotic injuries. Athletes with tenderness on palpation over the anterior interosseous membrane proximal to the ankle joint and positive special tests ~~such as ankle external, rotation~~ and syndesmosis squeeze

test were suspected for syndesmotic injury. Uncertainty of the diagnosis was resolved through widening of the tibiofibular joint seen during radiographic assessment, or ultrasonographic or magnetic resonance imaging (MRI) evidence of rupture of syndesmotic ligaments without associated fibula fracture. Data collection was undertaken in accordance with a previously published consensus statement regarding how to conduct epidemiological research in professional football.[19] Methodology related to the exposure and injury registration has previously been described in detail.[19]

Data analysis and statistics

Data were analysed using SPSS (IBM SPSS Statistics for Windows, V.23.0, IBM Corp, Armonk, New York, USA). Injury incidence was described as the number of injuries/1000 hours of exposure, with corresponding 95% confidence intervals (CI). Injury incidence in training and match play were calculated and rate ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset. The proportion of match injuries occurring in different 15-minute-periods of match halves were compared to the expected 33% proportion, which would be present if injuries were evenly distributed between the different thirds, and analysed with Z-statistics. Injury severity was defined by the number of days of absence caused by the injuries and described with mean (±SD) and median (25th and 75th percentile). Injury burden was defined as number of day's absence/1000 hours of exposure. Injury burden in training and match play were calculated and injury burden ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset.

The annual changes in injury incidence, injury burden, and syndesmotic injury proportion (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) were analysed using linear regression. In these analyses injury incidence, injury burden and syndesmotic injury proportion was used as dependent variables in separate analyses, while season was used as the independent variable in all analyses. In addition, injury incidence, injury burden and syndesmotic injury proportion in match play were also analysed using linear regression with season included as the independent variable. Analyses of training injuries specifically were not performed since the number of injuries during training were few.

To reduce possible effects of large temporary variations between seasons, moving averages (MA) of two consecutive seasons were also used as dependent variables in similar linear regression analyses. All analyses were two sided, and the significance level was set at $p<0.05$.

Results

Isolated syndesmotic injury incidence

The overall isolated syndesmotic injury incidence over the study period was 0.05 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury incidence during match play was 13 times higher compared to the incidence during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively (RR 12.63; 95% CI 8.12 to 19.65). A significant annual increase in isolated syndesmotic injury incidence in general (R^2=0.495, b=0.003, 95% CI 0.001 to 0.004, p=0.003) as well as in match play (R^2=0.354, b=0.013, 95% CI 0.002 to 0.023, p=0.019) was observed over the 15 seasons (figure 1).

The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in syndesmotic injury incidence in general (R^2=0.822, b=0.003, 95% CI 0.002 to 0.004, p<0.001) as well as in match play (R^2=0.751, b=0.015, 95% CI 0.009 to 0.020, p<0.001).

Isolated syndesmotic injury proportion of all ankle ligament injuries

Out of the 14 653 injuries registered during the 15 seasons 1950 (13%) affected the ankle with 1320 (9%) ankle ligament injuries. ~~Out of these 1320 injuries 94 (7%)~~ were diagnosed as syndesmotic injuries. An annual increase of the proportion of syndesmotic injuries (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) was observed (R^2=0.601, b=0.006, 95% CI 0.003 to 0.009, p=0.001) (figure 2). The proportion of syndesmotic injuries during match play also increased annually (R^2=0.430, b=0.006, 95% CI 0.002 to 0.010, p=0.008).

The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in the proportion of syndesmotic injuries in general (R^2=0.818, b=0.006, 95% CI 0.004 to 0.008, p<0.001) and in match play (R^2=0.758, b=0.006, 95% CI 0.004 to 0.009, p<0.001).

Injury patterns

Seventy percent of the syndesmotic injuries occurred during match play and the remaining 30% during training. Being tackled was responsible for one third of the syndesmotic injuries. The remaining injuries were accounted for by: twisting/turning (13%), landing from a jump (10%), collisions (5%), being kicked (5%), tackling (4%), other (10%), and for 20% the mechanism was unknown. Seventy-four percent of the injuries involved contact of some kind and 54% affected the dominant leg (defined as the preferred kicking leg). Seven percent were considered re-injuries. No significant differences were found between the proportion of injuries occurring during 15-minute-periods of each half (0-15, 16-30, 31-45 minutes) and the 33% which would be expected if the injuries were evenly distributed between the different thirds of the match halves (figure 3).

Injury severity and absence

More than 90% of the syndesmotic injuries were classified as moderate to severe (causing more than one week absence) with 57% being severe (causing more than one month absence). The mean (SD) absence following a syndesmotic injury was 39 (28) days and the median (25th, 75th percentiles) was 34 days (19, 52).

Isolated syndesmotic injury burden

A total of 3,652 days of absence due to syndesmotic injuries were reported over the study period, representing an injury burden of 1.8 days absent per /1000 hours of exposure. The injury burden due to match exposure was 18 (RR 18.22; 95% CI 16.86 to 19.68) times higher compared to training (8.8 days absent/1000 match hours versus 0.5 days absent per 1000 training hours). There were no significant annual changes in injury burden in general (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520) or in match play (R^2=0.003, b=0.060, 95% CI -0.598 to 0.718, p=0.847).

Similarly, no annual change in general (R^2=0.059, b=0.028, 95% CI -0.043 to 0.099, p=0.405) or in match play (R^2=0.005, b=0.050, 95% CI -0.389 to 0.488, p=0.809) was shown when the two-season moving average of injury burden was analysed (figure 4).

Discussion

The incidence figures indicate that an isolated syndesmotic injury in professional football is a relatively rare event. Despite this, the injury incidence during match play seems to have increased over the past 15 seasons. Return to play after injury took on average greater than 5 weeks.

Comparison with Other Sports

Isolated syndesmotic injuries are more common in collision sports and those that involve rigid immobilisation of the ankle in a boot.[20] In a cohort consisting of National Collegiate Athletic Association (NCAA) American football players the incidence of syndesmotic injury during games was 1.6 per 1000 athlete exposures (defined as one athlete participating in one practice or competition in which there was a possibility for athletic injury).[21] Flik et al.[8] collected injury data from 12 NCAA Division I ice hockey teams over one season and found that the game injury was 0.93 per 1000 athlete exposures. For rugby the injury rate per 1000 hours of exposure was 0.89 in Rugby Union and 0.46 in Rugby League.[22] In our study, the syndesmotic injury incidence rate during match play over the study period was 0.21 injuries per 1000 hours of exposure. Accounting 90 minutes exposure for each match played, the incidence of syndesmotic injury during games was 0.32 per 1000 athlete exposures. Hence, the risk of incurring a syndesmotic injury playing football is lower compared to American football, ice hockey, or rugby.

Professional versus non-professional football players

Mauntel et al.[15] described the epidemiology of isolated syndesmotic injuries among college student-athletes in 25 sports over six seasons. ~~Similarly with~~ our findings the injury incidence during match play was 0.34 per 1000 athlete exposures and the injury incidence during training was 0.047 per 1000 athlete exposures. Compared to professional players fewer injuries were caused by contact (74% among professional players versus 56% among non-professional players). Interestingly, the absence following an isolated syndesmotic injury was in 80% of the injuries less than 21 days. Previous studies, including ours have described an absence ranging from 30 to 62 days.[23-26] A possible explanation could be that some lateral ankle sprains may have been misdiagnosed and diagnosed as syndesmotic injuries instead. Unfortunately, the authors did not describe the methods used for diagnosing the injury.

Yearly Increase in Injury Incidence

Over the 15 seasons an annual increase in isolated syndesmotic injury incidence in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per 1.000 hours) was observed (figure 1). This might be a reflection of the fact that today's health care providers have greater suspicion for the injury, or perhaps because of the more frequent use of magnetic resonance imaging or diagnostic arthroscopy.[24 27] Another explanation could be a general philosophical change in the way clubs attend to player complaints.[28] Nonetheless, our data showed that being tackled caused most injuries, and the injury happened 13 times more frequently during match play then during a training session. Hence, we propose that the increase in annual injury incidence is caused by a more aggressive style of play during matches over the 15 years.

Low proportion of syndesmotic injury

Isolated syndesmotic injuries accounted for 7% of all ankle ligament injuries. The reported proportion of isolated syndesmotic injuries among overall ankle ligament injuries ranges from 18 to 74%.[8 10 21 25 29-31] This variation can be explained by the fact that some sports have extrinsic risk factors associated with syndesmotic injury. Skiers and ice hockey players wear boots causing rigid immobilisation of the ankle leading to high-torque external rotation of the foot,[5 8 25] and American football is often played on artificial turf instead of natural surfaces.[10 21 29 31] Another plausible explanation is that an isolated syndesmotic injury can be frequently misdiagnosed as an ankle sprain.

Injury burden

The average absence from play following a syndesmotic injury was 39 days. This is in line with findings from previous studies that reported prolonged time to return to play after a syndesmotic injury, ranging from 30 to 62 days.[23-26] In contrast, following lateral ankle sprains the absence has been reported 15 days.[32] In addition, over the course of 15 seasons we found no change in injury burden despite the injury incidence having increased. Hence, the time to return to play after injury over the past 15 seasons has decreased. A reason for this decrease could be that recent research on treatment strategies and diagnosing the severity of the injury may have lead to improved outcomes.[11 23 33-35] Nevertheless, to reduce the risk and consequences of this injury to a team, club medical staff should be conscious of whether the injury is stable or unstable since each requires different treatment strategies.[11] Appropriate management of syndesmotic injuries leads to

an earlier return to play.[23] In addition, use of ankle braces,[36] referees being stricter while judging player tackling, and changes to game play rules - such as sliding - may help reducing the injury incidence rate.

Strengths and study limitations

The strength of this study is the large homogenous data set prospectively collected among 61 professional football teams. Having many teams working together provides robust data from which to draw conclusions.[16 37] There are, however, a few limitations. We were not able to capture data on possible confounders and these could therefore not be included in our analyses. First, the injury form did not capture the examination findings or diagnostic tests results to classify syndesmotic injuries beyond identifying a lack of fracture, or provide information on associated injuries. Second, the diagnosis was made by the medical staff of each football team and thus subject to the biases and experience of different physicians. Increasing awareness of the diagnosis of 'syndesmosis injury' may explain part of the trend to increased incidence. Third, we did not capture data on pitch or weather conditions at the time of injury. Fourth, we did not capture data on player medical history (i.e., previous syndesmotic or ankle ligament injury). Fifth, there was no information available on how players were treated (i.e., conservatively or surgically). These data would have been useful to provide better perspective with respect to interpreting absentee time following the injury.

Conclusion

Our findings indicate a significant increase in the incidence of isolated syndesmotic injuries in professional football players. We speculate this is likely caused by more aggressive playing style during matches. The average return to play time following injury exceeded 5 weeks, and there was no change found in injury burden over 15 seasons. We recommend club medical staff to be conscious of the nature of the injury to reduce the consequences of such injuries to a team. ~~In addition, intensifying preventative work can help reducing the injury incidence rate.~~

Competing interests
There were no relationships/conditions/circumstances that present a potential conflict of interest

Authors' contributions
All authors were responsible for the conception and design of the study. HB and JE have been involved in the data collection over the study period. HB conducted the analyses, which were planned and checked with BL, and PD. All authors contributed to the interpretation of the findings. BL wrote the first draft of the paper, which was critically revised by PD, HB, CWD, JC and JE. The final manuscript has been approved by all authors.

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Ethical approval information:
The study design was approved by the UEFA Medical Committee and the UEFA Football Development Division.

Data sharing statement:
Due to confidentiality reasons there is no data that can be shared

References

1. Hermans JJ, Beumer A, de Jong TA, et al. Anatomy of the distal tibiofibular syndesmosis in adults: a pictorial essay with a multimodality approach. *Journal of anatomy* 2010;217(6):633-45. doi: 10.1111/j.1469-7580.2010.01302.x [published Online First: 2010/11/26]
2. Williams BT, Ahrberg AB, Goldsmith MT, et al. Ankle syndesmosis: a qualitative and quantitative anatomic analysis. *Am J Sports Med* 2015;43(1):88-97. doi: 10.1177/0363546514554911 [published Online First: 2014/11/02]
3. Beumer A, Valstar ER, Garling EH, et al. Effects of ligament sectioning on the kinematics of the distal tibiofibular syndesmosis: a radiostereometric study of 10 cadaveric specimens based on presumed trauma mechanisms with suggestions for treatment. *Acta orthopaedica* 2006;77(3):531-40. doi: 10.1080/17453670610012557 [published Online First: 2006/07/05]
4. Xenos JS, Hopkinson WJ, Mulligan ME, et al. The tibiofibular syndesmosis. Evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. *The Journal of bone and joint surgery American volume* 1995;77(6):847-56. [published Online First: 1995/06/01]
5. Fritschy D. An unusual ankle injury in top skiers. *Am J Sports Med* 1989;17(2):282-5; discussion 85-6. [published Online First: 1989/03/01]
6. Clanton TO, Paul P. Syndesmosis injuries in athletes. *Foot and ankle clinics* 2002;7(3):529-49.
7. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in National Hockey League players. *American Journal of Sports Medicine* 2004;32(8):1941-45.
8. Flik K, Lyman S, Marx RG. American collegiate men's ice hockey: an analysis of injuries. *Am J Sports Med* 2005;33(2):183-7. [published Online First: 2005/02/11]
9. Hopkinson WJ, St Pierre P, Ryan JB, et al. Syndesmosis sprains of the ankle. *Foot & ankle* 1990;10(6):325-30. [published Online First: 1990/06/01]
10. Kaplan LD, Jost PW, Honkamp N, et al. Incidence and variance of foot and ankle injuries in elite college football players. *Am J Orthop (Belle Mead NJ)* 2011;40(1):40-4. [published Online First: 2011/07/02]
11. Lubberts B, van Dijk PAD, Donovan N, et al. Time to return to sports after management of stable and unstable grade II syndesmotic injuries: a systematic review. JISAKOS Published Online. doi:10.1136/ jisakos-2015-000026. 2015
12. Nussbaum ED, Hosea TM, Sieler SD, et al. Prospective evaluation of syndesmotic ankle sprains without diastasis. *American Journal of Sports Medicine* 2001;29(1):31-35.
13. Vopat ML, Vopat BG, Lubberts B, et al. Current trends in the diagnosis and management of syndesmotic injury. *Current reviews in musculoskeletal medicine* 2017 doi: 10.1007/s12178-017-9389-4 [published Online First: 2017/01/20]
14. Gerber JP, Williams GN, Scoville CR, et al. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot & ankle international* 1998;19(10):653-60.
15. Mauntel TC, Wikstrom EA, Roos KG, et al. The Epidemiology of High Ankle Sprains in National Collegiate Athletic Association Sports. *Am J Sports Med*

2017:363546517701428. doi: 10.1177/0363546517701428 [published Online First: 2017/04/20]
16. Ekstrand J. Preventing injuries in professional football: thinking bigger and working together. *Br J Sports Med* 2016;50(12):709-10. doi: 10.1136/bjsports-2016-096333 [published Online First: 2016/04/29]
17. Walden M, Hagglund 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(8):542-6. doi: 10.1136/bjsm.2004.014571 [published Online First: 2005/07/28]
18. Orchard J. Orchard Sports Injury Classification System (OSICS). *Sports health* 1993;11:39- 41.
19. Hagglund M, Walden M, Bahr R, et al. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med* 2005;39(6):340-6. doi: 10.1136/bjsm.2005.018267 [published Online First: 2005/05/25]
20. Williams GN, Jones MH, Amendola A. Syndesmotic ankle sprains in athletes. *Am J Sports Med* 2007;35(7):1197-207. doi: 10.1177/0363546507302545 [published Online First: 2007/05/24]
21. Hunt KJ, George E, Harris AH, et al. Epidemiology of syndesmosis injuries in intercollegiate football: incidence and risk factors from National Collegiate Athletic Association injury surveillance system data from 2004-2005 to 2008-2009. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2013;23(4):278-82. doi: 10.1097/JSM.0b013e31827ee829 [published Online First: 2013/01/24]
22. Sman AD, Hiller CE, Rae K, et al. Predictive factors for ankle syndesmosis injury in football players: a prospective study. *Journal of science and medicine in sport* 2014;17(6):586-90. doi: 10.1016/j.jsams.2013.12.009 [published Online First: 2014/01/28]
23. Calder JD, Bamford R, Petrie A, et al. Stable Versus Unstable Grade II High Ankle Sprains: A Prospective Study Predicting the Need for Surgical Stabilization and Time to Return to Sports. *Arthroscopy* 2015 doi: 10.1016/j.arthro.2015.10.003 [published Online First: 2016/01/05]
24. Howard DR, Rubin DA, Hillen TJ, et al. Magnetic resonance imaging as a predictor of return to play following syndesmosis (high) ankle sprains in professional football players. *Sports health* 2012;4(6):535-43. doi: 10.1177/1941738112462531 [published Online First: 2013/11/02]
25. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in national hockey league players. *Am J Sports Med* 2004;32(8):1941-5. [published Online First: 2004/12/02]
26. Sman AD, Hiller CE, Rae K, et al. Prognosis of ankle syndesmosis injury. *Medicine and science in sports and exercise* 2014;46(4):671-7. doi: 10.1249/mss.0000000000000151 [published Online First: 2013/09/05]
27. Takao M, Ochi M, Oae K, et al. Diagnosis of a tear of the tibiofibular syndesmosis. The role of arthroscopy of the ankle. *The Journal of bone and joint surgery British volume* 2003;85(3):324-9. [published Online First: 2003/05/06]

28. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical officers. *Br J Sports Med* 2016;50(12):725-30. doi: 10.1136/bjsports-2015-095259 [published Online First: 2016/01/23]
29. Boytim MJ, Fischer DA, Neumann L. Syndesmotic ankle sprains. *American Journal of Sports Medicine* 1991;19(3):294-98.
30. Roemer FW, Jomaah N, Niu J, et al. Ligamentous Injuries and the Risk of Associated Tissue Damage in Acute Ankle Sprains in Athletes: A Cross-sectional MRI Study. *Am J Sports Med* 2014;42(7):1549-57. doi: 10.1177/0363546514529643
31. Osbahr DC, Drakos MC, O'Loughlin PF, et al. Syndesmosis and lateral ankle sprains in the National Football League. *Orthopedics* 2013;36(11):e1378-e84.
32. Walden M, Hagglund M, Ekstrand J. Time-trends and circumstances surrounding ankle injuries in men's professional football: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med* 2013;47(12):748-53. doi: 10.1136/bjsports-2013-092223 [published Online First: 2013/07/03]
33. Westermann RW, Rungprai C, Goetz JE, et al. The effect of suture-button fixation on simulated syndesmotic malreduction: a cadaveric study. *The Journal of bone and joint surgery American volume* 2014;96(20):1732-8. doi: 10.2106/jbjs.n.00198 [published Online First: 2014/10/17]
34. Forschner PF, Beitzel K, Imhoff AB, et al. Five-Year Outcomes After Treatment for Acute Instability of the Tibiofibular Syndesmosis Using a Suture-Button Fixation System. *Orthopaedic journal of sports medicine* 2017;5(4):2325967117702854. doi: 10.1177/2325967117702854 [published Online First: 2017/05/17]
35. Ryan PM, Rodriguez RM. Outcomes and Return to Activity After Operative Repair of Chronic Latent Syndesmotic Instability. *Foot & ankle international* 2016;37(2):192-7. doi: 10.1177/1071100715606488 [published Online First: 2015/09/20]
36. McGuine TA, Hetzel S, Wilson J, et al. The effect of lace-up ankle braces on injury rates in high school football players. *Am J Sports Med* 2012;40(1):49-57. doi: 10.1177/0363546511422332 [published Online First: 2011/09/20]
37. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med* 2011;45(7):553-8. doi: 10.1136/bjsm.2009.060582 [published Online First: 2009/06/26]

Figure legends

Figure 1: Seasonal variation in injury incidence of syndesmotic injuries in professional football. *MA*, moving average;

Figure 2: Seasonal variation of the proportion of syndesmotic injuries of all ankle ligament injuries in professional football.
MA, moving average;

Figure 3: Distribution of syndesmotic injuries during 15 min periods of match play in professional football;

Figure 4: Seasonal variation in injury burden of syndesmotic injuries in professional football. *MA*, moving average;

Table 1 Overview of amount of teams, exposure, and injuries per season

Season	Teams	Exp. Total (hours)	Exp. training (hours)	Exp. Match (hours)	Ankle ligament injuries (total)(ii)	Ankle ligament injuries (training)(ii)	Ankle ligament injuries (match)(ii)	Syn. injuries (total)(ii)	Syn. injuries (training) (ii)	Syn. injuries (match)(ii)
01/02	11	69447	57915	11532	71 (1.02)	38 (0.66)	33 (2.86)	1 (0.01)	0 (0.00)	1 (0.09)
02/03	9	61777	51824	9954	41 (0.66)	12 (0.23)	29 (2.91)	1 (0.02)	0 (0.00)	1 (0.10)
03/04	11	64639	53866	10773	49 (0.76)	23 (0.43)	26 (2.41)	3 (0.05)	2 (0.04)	1 (0.09)
04/05	9	58257	48753	9504	44 (0.76)	18 (0.37)	26 (2.74)	2 (0.03)	0 (0.00)	2 (0.21)
05/06	17	102017	85446	16571	65 (0.64)	21 (0.25)	44 (2.66)	3 (0.03)	0 (0.00)	3 (0.18)
06/07	17	110658	93471	17187	89 (0.80)	43 (0.46)	46 (2.68)	3 (0.03)	3 (0.03)	0 (0.00)
07/08	14	95630	80294	15336	58 (0.61)	22 (0.27)	36 (2.35)	5 (0.05)	1 (0.01)	4 (0.26)
08/09	14	99181	83698	15483	77 (0.78)	31 (0.37)	46 (2.97)	3 (0.03)	1 (0.01)	2 (0.13)
09/10	18	123751	104534	19216	73 (0.59)	24 (0.23)	49 (2.55)	7 (0.06)	2 (0.02)	5 (0.26)
10/11	20	132314	110755	21559	83 (0.63)	38 (0.34)	45 (2.09)	5 (0.04)	2 (0.02)	3 (0.14)
11/12	31	213787	180742	33045	145 (0.68)	55 (0.30)	90 (2.72)	10 (0.05)	4 (0.02)	6 (0.18)
12/13	34	210069	176202	33868	162 (0.77)	54 (0.31)	108 (3.19)	11 (0.05)	2 (0.01)	9 (0.27)
13/14	39	257517	216619	40898	154 (0.60)	50 (0.23)	104 (2.54)	15 (0.06)	4 (0.02)	11 (0.27)
14/15	31	229372	195124	34247	118 (0.51)	36 (0.18)	82 (2.39)	17 (0.07)	4 (0.02)	13 (0.38)
15/16	29	208765	177506	31259	91 (0.44)	33 (0.19)	58 (1.86)	8 (0.04)	3 (0.02)	5 (0.16)

Exp; exposure, Syn; syndesmotic, ii; Injury incidence/1,000 exposure hours

Table 2 Definitions of variables used in the study

Training session	Team training that involved physical activity under the supervision of the coaching staff
Match	Competitive or friendly match against another team
Time loss injury	Any physical complaint sustained by a player that resulted from a football match or football training and led to the player being unable to take a full part in future football training or match play
Moderate injury	Injury causing 8–28 days absence
Severe injury	Injury causing >28 days absence
Re-injury	Injury of the same type and at the same site as an index injury
Injury incidence	Number of injuries per 1000 player-hours ((Σ injuries/Σ exposure-hours)×1000)
Injury burden	Number of days absence per 1000 player-hours ((Σ days absence / Σ exposure-hours)×1000)

Epidemiology and return to play following isolated syndesmotic injuries of the ankle: a prospective cohort study of 3677 male professional footballers in the UEFA Elite Club Injury Study

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Abstract

Aim

To determine the epidemiology of isolated syndesmotic injuries in professional football players.

Methods

Data from 15 consecutive seasons of European professional football between 2001 and 2016 contributed to the dataset of this study. Match-play and training data from a total of 3677 players from 61 teams across 17 countries have been included. Team medical staff recorded player exposure and time loss injuries. Injury incidence was defined as the number of injuries per 1000 player-hours. Injury burden was defined as number of days absence per 1000 player-hours. Seasonal trends for isolated syndesmotic injury incidence, isolated syndesmotic injury proportion of ankle ligament injuries, and isolated syndesmotic injury burden were analysed via linear regression.

Results

The isolated syndesmotic injury incidence was 0.05 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury incidence during match play was 13 times higher compared to during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively. Out of the 1320 ankle ligament injuries registered during the 15 seasons 94 (7%) were diagnosed as isolated syndesmotic injuries. An annual increase in injury incidence was observed (R^2=0.495,

b=0.003, 95% CI 0.001 to 0.004, p=0.003). However, no significant annual change of injury burden was observed (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520). 74% of the injuries were contact related and the mean (+/- SD) absence following an isolated syndesmotic injury was 39 (+/- 28) days.

Conclusions

The incidence of isolated syndesmotic injuries in elite professional European football annually increased between 2001-16.

Key Words: syndesmosis, high ankle sprain, incidence, football, epidemiology

What are the new findings

- Injury incidence during match play has increased over the past 15 seasons
- Isolated syndesmotic injury in football is most commonly caused by tackling
- Average return to play after injury exceeds 5 weeks

How might it impact on clinical practice in the near future

- Our findings may assist in making football players, coaches, referees and the club medical staff aware of isolated syndesmotic injury and its consequences
- Our findings may contribute to the development of injury prevention strategies in football as they demonstrate that isolated syndesmotic injuries are most commonly caused by player-tackling

Introduction

Ankle syndesmosis injury may occur in many forms, commonly classified into isolated ankle syndesmosis injury or with an associated fibula fracture. An isolated injury may occur to any one of the three distinct ligaments (the anterior inferior tibiofibular ligament, the interosseous tibiofibular ligament, and the posterior inferior tibiofibular ligament),[1 2] but will most commonly involve the anterior inferior tibiofibular ligament.[3 4] The most common mechanisms of syndesmotic ligament injury are ankle external rotation and hyperdorsiflexion, causing the talus to rotate in the mortise and the fibula to rotate externally and moving posteriorly and laterally, providing stress to the anterior inferior tibiofibular ligament.[3-5]

Isolated syndesmotic injuries occur more commonly in athletes than in the general population.[5-13] Certain sports are characterised by a higher proportion of ankle syndesmosis injuries; these include boot immobilised sports[5-8] such as skiing and ice-hockey, as well as collision sports such as American football, wrestling, and rugby.[9 10 12 14]

For football, however, epidemiological data on isolated syndesmotic injuries is limited. Mauntel et al.[15] studied isolated syndesmotic injuries in 25 sports during six seasons and described the incidence rate, injury mechanism, recurrence, and time to return to activity of non-professional football players. Due to differences in competition level, speed of the game, body shape of the players, and playing calendar it is expected that epidemiology and etiology of syndesmotic injuries differ between non-professional and professional players. A better understanding of how and when professional players incur these injuries may help the development of preventive strategies as well as

providing important data regarding expected return to play times.[16]

We aimed to determine the injury incidence and epidemiology of isolated syndesmotic injuries of the ankle in professional football players over a 15 year period. In addition, we assessed the time to return to competition following an injury.

Material and methods

This is a substudy of a long-term prospective cohort study evaluating men's professional football in Europe since 2001.[17] The current study includes data from 15 consecutive seasons of European professional football between 2001 and 2016. During the study period, a total of 3677 players from 61 teams representing 17 countries have been included (table 1).

Exposure and injury registration

All first team players in included teams were invited to participate in the study. Participation was voluntary and written informed consent was obtained at the time of study inclusion. At the beginning of every season, teams appointed a contact person within each respective medical team to be responsible for collecting data and communicating with the study group. During the study period, all individual player exposure during supervised training sessions and matches was recorded on standard attendance records. In addition, all time loss injuries that occurred were registered on standard injury cards containing information about type of injury and circumstances of the injury occasion (ie. injury mechanism, affected side, time of injury, re-injury)(table 2). Each month, the appointed contact person reported the attendance records and injury cards to the study group. All injuries were given a diagnostic code by the study group in accordance with the Orchard Sports Injury Classification System (OSICS) 2.0.[18] OSICS 2.0 codes were used to identify isolated ankle syndesmotic injuries. Athletes with tenderness on palpation over the anterior interosseous membrane proximal to the ankle joint and positive special tests such as ankle external, rotation and syndesmosis squeeze

test were suspected for syndesmotic injury. Uncertainty of the diagnosis was resolved through widening of the tibiofibular joint seen during radiographic assessment, or ultrasonographic or magnetic resonance imaging (MRI) evidence of rupture of syndesmotic ligaments without associated fibula fracture. Data collection was undertaken in accordance with a previously published consensus statement regarding how to conduct epidemiological research in professional football.[19] Methodology related to the exposure and injury registration has previously been described in detail.[19]

Data analysis and statistics

Data were analysed using SPSS (IBM SPSS Statistics for Windows, V.23.0, IBM Corp, Armonk, New York, USA). Injury incidence was described as the number of injuries/1000 hours of exposure, with corresponding 95% confidence intervals (CI). Injury incidence in training and match play were calculated and rate ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset. The proportion of match injuries occurring in different 15-minute-periods of match halves were compared to the expected 33% proportion, which would be present if injuries were evenly distributed between the different thirds, and analysed with Z-statistics. Injury severity was defined by the number of days of absence caused by the injuries and described with mean (±SD) and median (25th and 75th percentile). Injury burden was defined as number of day's absence/1000 hours of exposure. Injury burden in training and match play were calculated and injury burden ratio between training and match play were analysed with Poisson regressions using match exposure hours as an offset.

The annual changes in injury incidence, injury burden, and syndesmotic injury proportion (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) were analysed using linear regression. In these analyses injury incidence, injury burden and syndesmotic injury proportion was used as dependent variables in separate analyses, while season was used as the independent variable in all analyses. In addition, injury incidence, injury burden and syndesmotic injury proportion in match play were also analysed using linear regression with season included as the independent variable. Analyses of training injuries specifically were not performed since the number of injuries during training were few.

To reduce possible effects of large temporary variations between seasons, moving averages (MA) of two consecutive seasons were also used as dependent variables in similar linear regression analyses. All analyses were two sided, and the significance level was set at $p<0.05$.

Results

Isolated syndesmotic injury incidence

The overall isolated syndesmotic injury incidence over the study period was 0.05 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury incidence during match play was 13 times higher compared to the incidence during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively (RR 12.63; 95% CI 8.12 to 19.65). A significant annual increase in isolated syndesmotic injury incidence in general (R^2=0.495, b=0.003, 95% CI 0.001 to 0.004, p=0.003) as well as in match play (R^2=0.354, b=0.013, 95% CI 0.002 to 0.023, p=0.019) was observed over the 15 seasons (figure 1).

The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in syndesmotic injury incidence in general (R^2=0.822, b=0.003, 95% CI 0.002 to 0.004, p<0.001) as well as in match play (R^2=0.751, b=0.015, 95% CI 0.009 to 0.020, p<0.001).

Isolated syndesmotic injury proportion of all ankle ligament injuries

Out of the 14 653 injuries registered during the 15 seasons 1950 (13%) affected the ankle with 1320 (9%) ankle ligament injuries. Out of these 1320 injuries 94 (7%) were diagnosed as syndesmotic injuries. An annual increase of the proportion of syndesmotic injuries (proportion of all ankle ligament injuries that were diagnosed as syndesmotic injuries) was observed (R^2=0.601, b=0.006, 95% CI 0.003 to 0.009, p=0.001) (figure 2). The proportion of syndesmotic injuries during match play also increased annually (R^2=0.430, b=0.006, 95% CI 0.002 to 0.010, p=0.008).

The sensitivity analyses, using moving averages of two consecutive seasons, also showed an annual increase in the proportion of syndesmotic injuries in general (R^2=0.818, b=0.006, 95% CI 0.004 to 0.008, p<0.001) and in match play (R^2=0.758, b=0.006, 95% CI 0.004 to 0.009, p<0.001).

Injury patterns

Seventy percent of the syndesmotic injuries occurred during match play and the remaining 30% during training. Being tackled was responsible for one third of the syndesmotic injuries. The remaining injuries were accounted for by: twisting/turning (13%), landing from a jump (10%), collisions (5%), being kicked (5%), tackling (4%), other (10%), and for 20% the mechanism was unknown. Seventy-four percent of the injuries involved contact of some kind and 54% affected the dominant leg (defined as the preferred kicking leg). Seven percent were considered re-injuries. No significant differences were found between the proportion of injuries occurring during 15-minute-periods of each half (0-15, 16-30, 31-45 minutes) and the 33% which would be expected if the injuries were evenly distributed between the different thirds of the match halves (figure 3).

Injury severity and absence

More than 90% of the syndesmotic injuries were classified as moderate to severe (causing more than one week absence) with 57% being severe (causing more than one month absence). The mean (SD) absence following a syndesmotic injury was 39 (28) days and the median (25th, 75th percentiles) was 34 days (19, 52).

Isolated syndesmotic injury burden

A total of 3,652 days of absence due to syndesmotic injuries were reported over the study period, representing an injury burden of 1.8 days absent per /1000 hours of exposure. The injury burden due to match exposure was 18 (RR 18.22; 95% CI 16.86 to 19.68) times higher compared to training (8.8 days absent/1000 match hours versus 0.5 days absent per 1000 training hours). There were no significant annual changes in injury burden in general (R^2=0.033, b=0.032, 95% CI -0.073 to 0.138, p=0.520) or in match play (R^2=0.003, b=0.060, 95% CI -0.598 to 0.718, p=0.847).

Similarly, no annual change in general (R^2=0.059, b=0.028, 95% CI -0.043 to 0.099, p=0.405) or in match play (R^2=0.005, b=0.050, 95% CI -0.389 to 0.488, p=0.809) was shown when the two-season moving average of injury burden was analysed (figure 4).

Discussion

The incidence figures indicate that an isolated syndesmotic injury in professional football is a relatively rare event. Despite this, the injury incidence during match play seems to have increased over the past 15 seasons. Return to play after injury took on average greater than 5 weeks.

Comparison with Other Sports

Isolated syndesmotic injuries are more common in collision sports and those that involve rigid immobilisation of the ankle in a boot.[20] In a cohort consisting of National Collegiate Athletic Association (NCAA) American football players the incidence of syndesmotic injury during games was 1.6 per 1000 athlete exposures (defined as one athlete participating in one practice or competition in which there was a possibility for athletic injury).[21] Flik et al.[8] collected injury data from 12 NCAA Division I ice hockey teams over one season and found that the game injury was 0.93 per 1000 athlete exposures. For rugby the injury rate per 1000 hours of exposure was 0.89 in Rugby Union and 0.46 in Rugby League.[22] In our study, the syndesmotic injury incidence rate during match play over the study period was 0.21 injuries per 1000 hours of exposure. Accounting 90 minutes exposure for each match played, the incidence of syndesmotic injury during games was 0.32 per 1000 athlete exposures. Hence, the risk of incurring a syndesmotic injury playing football is lower compared to American football, ice hockey, or rugby.

Professional versus non-professional football players

Mauntel et al.[15] described the epidemiology of isolated syndesmotic injuries among college student-athletes in 25 sports over six seasons. Similarly with our findings the injury incidence during match play was 0.34 per 1000 athlete exposures and the injury incidence during training was 0.047 per 1000 athlete exposures. Compared to professional players fewer injuries were caused by contact (74% among professional players versus 56% among non-professional players). Interestingly, the absence following an isolated syndesmotic injury was in 80% of the injuries less than 21 days. Previous studies, including ours have described an absence ranging from 30 to 62 days.[23-26] A possible explanation could be that some lateral ankle sprains may have been misdiagnosed and diagnosed as syndesmotic injuries instead. Unfortunately, the authors did not describe the methods used for diagnosing the injury.

Yearly Increase in Injury Incidence

Over the 15 seasons an annual increase in isolated syndesmotic injury incidence in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per 1.000 hours) was observed (figure 1). This might be a reflection of the fact that today's health care providers have greater suspicion for the injury, or perhaps because of the more frequent use of magnetic resonance imaging or diagnostic arthroscopy.[24 27] Another explanation could be a general philosophical change in the way clubs attend to player complaints.[28] Nonetheless, our data showed that being tackled caused most injuries, and the injury happened 13 times more frequently during match play then during a training session. Hence, we propose that the increase in annual injury incidence is caused by a more aggressive style of play during matches over the 15 years.

Low proportion of syndesmotic injury

Isolated syndesmotic injuries accounted for 7% of all ankle ligament injuries. The reported proportion of isolated syndesmotic injuries among overall ankle ligament injuries ranges from 18 to 74%.[8 10 21 25 29-31] This variation can be explained by the fact that some sports have extrinsic risk factors associated with syndesmotic injury. Skiers and ice hockey players wear boots causing rigid immobilisation of the ankle leading to high-torque external rotation of the foot,[5 8 25] and American football is often played on artificial turf instead of natural surfaces.[10 21 29 31] Another plausible explanation is that an isolated syndesmotic injury can be frequently misdiagnosed as an ankle sprain.

Injury burden

The average absence from play following a syndesmotic injury was 39 days. This is in line with findings from previous studies that reported prolonged time to return to play after a syndesmotic injury, ranging from 30 to 62 days.[23-26] In contrast, following lateral ankle sprains the absence has been reported 15 days.[32] In addition, over the course of 15 seasons we found no change in injury burden despite the injury incidence having increased. Hence, the time to return to play after injury over the past 15 seasons has decreased. A reason for this decrease could be that recent research on treatment strategies and diagnosing the severity of the injury may have lead to improved outcomes.[11 23 33-35] Nevertheless, to reduce the risk and consequences of this injury to a team, club medical staff should be conscious of whether the injury is stable or unstable since each requires different treatment strategies.[11] Appropriate management of syndesmotic injuries leads to

an earlier return to play.[23] In addition, use of ankle braces,[36] referees being stricter while judging player tackling, and changes to game play rules - such as sliding - may help reducing the injury incidence rate.

Strengths and study limitations

The strength of this study is the large homogenous data set prospectively collected among 61 professional football teams. Having many teams working together provides robust data from which to draw conclusions.[16 37] There are, however, a few limitations. We were not able to capture data on possible confounders and these could therefore not be included in our analyses. First, the injury form did not capture the examination findings or diagnostic tests results to classify syndesmotic injuries beyond identifying a lack of fracture, or provide information on associated injuries. Second, the diagnosis was made by the medical staff of each football team and thus subject to the biases and experience of different physicians. Increasing awareness of the diagnosis of 'syndesmosis injury' may explain part of the trend to increased incidence. Third, we did not capture data on pitch or weather conditions at the time of injury. Fourth, we did not capture data on player medical history (i.e., previous syndesmotic or ankle ligament injury). Fifth, there was no information available on how players were treated (i.e., conservatively or surgically). These data would have been useful to provide better perspective with respect to interpreting absentee time following the injury.

Conclusion

Our findings indicate a significant increase in the incidence of isolated syndesmotic injuries in professional football players. We speculate this is likely caused by more aggressive playing style during matches. The average return to play time following injury exceeded 5 weeks, and there was no change found in injury burden over 15 seasons. We recommend club medical staff to be conscious of the nature of the injury to reduce the consequences of such injuries to a team. In addition, intensifying preventative work can help reducing the injury incidence rate.

Competing interests
There were no relationships/conditions/circumstances that present a potential conflict of interest

Authors' contributions
All authors were responsible for the conception and design of the study. HB and JE have been involved in the data collection over the study period. HB conducted the analyses, which were planned and checked with BL, and PD. All authors contributed to the interpretation of the findings. BL wrote the first draft of the paper, which was critically revised by PD, HB, CWD, JC and JE. The final manuscript has been approved by all authors.

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The study design was approved by the UEFA Medical Committee and the UEFA Football Development Division.

Data sharing statement:
Due to confidentiality reasons there is no data that can be shared

References

1. Hermans JJ, Beumer A, de Jong TA, et al. Anatomy of the distal tibiofibular syndesmosis in adults: a pictorial essay with a multimodality approach. *Journal of anatomy* 2010;217(6):633-45. doi: 10.1111/j.1469-7580.2010.01302.x [published Online First: 2010/11/26]
2. Williams BT, Ahrberg AB, Goldsmith MT, et al. Ankle syndesmosis: a qualitative and quantitative anatomic analysis. *Am J Sports Med* 2015;43(1):88-97. doi: 10.1177/0363546514554911 [published Online First: 2014/11/02]
3. Beumer A, Valstar ER, Garling EH, et al. Effects of ligament sectioning on the kinematics of the distal tibiofibular syndesmosis: a radiostereometric study of 10 cadaveric specimens based on presumed trauma mechanisms with suggestions for treatment. *Acta orthopaedica* 2006;77(3):531-40. doi: 10.1080/17453670610012557 [published Online First: 2006/07/05]
4. Xenos JS, Hopkinson WJ, Mulligan ME, et al. The tibiofibular syndesmosis. Evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. *The Journal of bone and joint surgery American volume* 1995;77(6):847-56. [published Online First: 1995/06/01]
5. Fritschy D. An unusual ankle injury in top skiers. *Am J Sports Med* 1989;17(2):282-5; discussion 85-6. [published Online First: 1989/03/01]
6. Clanton TO, Paul P. Syndesmosis injuries in athletes. *Foot and ankle clinics* 2002;7(3):529-49.
7. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in National Hockey League players. *American Journal of Sports Medicine* 2004;32(8):1941-45.
8. Flik K, Lyman S, Marx RG. American collegiate men's ice hockey: an analysis of injuries. *Am J Sports Med* 2005;33(2):183-7. [published Online First: 2005/02/11]
9. Hopkinson WJ, St Pierre P, Ryan JB, et al. Syndesmosis sprains of the ankle. *Foot & ankle* 1990;10(6):325-30. [published Online First: 1990/06/01]
10. Kaplan LD, Jost PW, Honkamp N, et al. Incidence and variance of foot and ankle injuries in elite college football players. *Am J Orthop (Belle Mead NJ)* 2011;40(1):40-4. [published Online First: 2011/07/02]
11. Lubberts B, van Dijk PAD, Donovan N, et al. Time to return to sports after management of stable and unstable grade II syndesmotic injuries: a systematic review. JISAKOS Published Online. doi:10.1136/ jisakos-2015-000026. 2015
12. Nussbaum ED, Hosea TM, Sieler SD, et al. Prospective evaluation of syndesmotic ankle sprains without diastasis. *American Journal of Sports Medicine* 2001;29(1):31-35.
13. Vopat ML, Vopat BG, Lubberts B, et al. Current trends in the diagnosis and management of syndesmotic injury. *Current reviews in musculoskeletal medicine* 2017 doi: 10.1007/s12178-017-9389-4 [published Online First: 2017/01/20]
14. Gerber JP, Williams GN, Scoville CR, et al. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot & ankle international* 1998;19(10):653-60.
15. Mauntel TC, Wikstrom EA, Roos KG, et al. The Epidemiology of High Ankle Sprains in National Collegiate Athletic Association Sports. *Am J Sports Med*

2017:363546517701428. doi: 10.1177/0363546517701428 [published Online First: 2017/04/20]
16. Ekstrand J. Preventing injuries in professional football: thinking bigger and working together. *Br J Sports Med* 2016;50(12):709-10. doi: 10.1136/bjsports-2016-096333 [published Online First: 2016/04/29]
17. Walden M, Hagglund 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(8):542-6. doi: 10.1136/bjsm.2004.014571 [published Online First: 2005/07/28]
18. Orchard J. Orchard Sports Injury Classification System (OSICS). *Sports health* 1993;11:39- 41.
19. Hagglund M, Walden M, Bahr R, et al. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med* 2005;39(6):340-6. doi: 10.1136/bjsm.2005.018267 [published Online First: 2005/05/25]
20. Williams GN, Jones MH, Amendola A. Syndesmotic ankle sprains in athletes. *Am J Sports Med* 2007;35(7):1197-207. doi: 10.1177/0363546507302545 [published Online First: 2007/05/24]
21. Hunt KJ, George E, Harris AH, et al. Epidemiology of syndesmosis injuries in intercollegiate football: incidence and risk factors from National Collegiate Athletic Association injury surveillance system data from 2004-2005 to 2008-2009. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2013;23(4):278-82. doi: 10.1097/JSM.0b013e31827ee829 [published Online First: 2013/01/24]
22. Sman AD, Hiller CE, Rae K, et al. Predictive factors for ankle syndesmosis injury in football players: a prospective study. *Journal of science and medicine in sport* 2014;17(6):586-90. doi: 10.1016/j.jsams.2013.12.009 [published Online First: 2014/01/28]
23. Calder JD, Bamford R, Petrie A, et al. Stable Versus Unstable Grade II High Ankle Sprains: A Prospective Study Predicting the Need for Surgical Stabilization and Time to Return to Sports. *Arthroscopy* 2015 doi: 10.1016/j.arthro.2015.10.003 [published Online First: 2016/01/05]
24. Howard DR, Rubin DA, Hillen TJ, et al. Magnetic resonance imaging as a predictor of return to play following syndesmosis (high) ankle sprains in professional football players. *Sports health* 2012;4(6):535-43. doi: 10.1177/1941738112462531 [published Online First: 2013/11/02]
25. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in national hockey league players. *Am J Sports Med* 2004;32(8):1941-5. [published Online First: 2004/12/02]
26. Sman AD, Hiller CE, Rae K, et al. Prognosis of ankle syndesmosis injury. *Medicine and science in sports and exercise* 2014;46(4):671-7. doi: 10.1249/mss.0000000000000151 [published Online First: 2013/09/05]
27. Takao M, Ochi M, Oae K, et al. Diagnosis of a tear of the tibiofibular syndesmosis. The role of arthroscopy of the ankle. *The Journal of bone and joint surgery British volume* 2003;85(3):324-9. [published Online First: 2003/05/06]

28. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical officers. *Br J Sports Med* 2016;50(12):725-30. doi: 10.1136/bjsports-2015-095259 [published Online First: 2016/01/23]
29. Boytim MJ, Fischer DA, Neumann L. Syndesmotic ankle sprains. *American Journal of Sports Medicine* 1991;19(3):294-98.
30. Roemer FW, Jomaah N, Niu J, et al. Ligamentous Injuries and the Risk of Associated Tissue Damage in Acute Ankle Sprains in Athletes: A Cross-sectional MRI Study. *Am J Sports Med* 2014;42(7):1549-57. doi: 10.1177/0363546514529643
31. Osbahr DC, Drakos MC, O'Loughlin PF, et al. Syndesmosis and lateral ankle sprains in the National Football League. *Orthopedics* 2013;36(11):e1378-e84.
32. Walden M, Hagglund M, Ekstrand J. Time-trends and circumstances surrounding ankle injuries in men's professional football: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med* 2013;47(12):748-53. doi: 10.1136/bjsports-2013-092223 [published Online First: 2013/07/03]
33. Westermann RW, Rungprai C, Goetz JE, et al. The effect of suture-button fixation on simulated syndesmotic malreduction: a cadaveric study. *The Journal of bone and joint surgery American volume* 2014;96(20):1732-8. doi: 10.2106/jbjs.n.00198 [published Online First: 2014/10/17]
34. Forschner PF, Beitzel K, Imhoff AB, et al. Five-Year Outcomes After Treatment for Acute Instability of the Tibiofibular Syndesmosis Using a Suture-Button Fixation System. *Orthopaedic journal of sports medicine* 2017;5(4):2325967117702854. doi: 10.1177/2325967117702854 [published Online First: 2017/05/17]
35. Ryan PM, Rodriguez RM. Outcomes and Return to Activity After Operative Repair of Chronic Latent Syndesmotic Instability. *Foot & ankle international* 2016;37(2):192-7. doi: 10.1177/1071100715606488 [published Online First: 2015/09/20]
36. McGuine TA, Hetzel S, Wilson J, et al. The effect of lace-up ankle braces on injury rates in high school football players. *Am J Sports Med* 2012;40(1):49-57. doi: 10.1177/0363546511422332 [published Online First: 2011/09/20]
37. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med* 2011;45(7):553-8. doi: 10.1136/bjsm.2009.060582 [published Online First: 2009/06/26]

Figure legends

Figure 1: Seasonal variation in injury incidence of syndesmotic injuries in professional football. *MA*, moving average;

Figure 2: Seasonal variation of the proportion of syndesmotic injuries of all ankle ligament injuries in professional football.
MA, moving average;

Figure 3: Distribution of syndesmotic injuries during 15 min periods of match play in professional football;

Figure 4: Seasonal variation in injury burden of syndesmotic injuries in professional football. *MA*, moving average;

Table 1 Overview of amount of teams, exposure, and injuries per season

Season	Teams	Exp. Total (hours)	Exp. training (hours)	Exp. Match (hours)	Ankle ligament injuries (total)(ii)	Ankle ligament injuries (training)(ii)	Ankle ligament injuries (match)(ii)	Syn. injuries (total)(ii)	Syn. injuries (training) (ii)	Syn. injuries (match)(ii)
01/02	11	69447	57915	11532	71 (1.02)	38 (0.66)	33 (2.86)	1 (0.01)	0 (0.00)	1 (0.09)
02/03	9	61777	51824	9954	41 (0.66)	12 (0.23)	29 (2.91)	1 (0.02)	0 (0.00)	1 (0.10)
03/04	11	64639	53866	10773	49 (0.76)	23 (0.43)	26 (2.41)	3 (0.05)	2 (0.04)	1 (0.09)
04/05	9	58257	48753	9504	44 (0.76)	18 (0.37)	26 (2.74)	2 (0.03)	0 (0.00)	2 (0.21)
05/06	17	102017	85446	16571	65 (0.64)	21 (0.25)	44 (2.66)	3 (0.03)	0 (0.00)	3 (0.18)
06/07	17	110658	93471	17187	89 (0.80)	43 (0.46)	46 (2.68)	3 (0.03)	3 (0.03)	0 (0.00)
07/08	14	95630	80294	15336	58 (0.61)	22 (0.27)	36 (2.35)	5 (0.05)	1 (0.01)	4 (0.26)
08/09	14	99181	83698	15483	77 (0.78)	31 (0.37)	46 (2.97)	3 (0.03)	1 (0.01)	2 (0.13)
09/10	18	123751	104534	19216	73 (0.59)	24 (0.23)	49 (2.55)	7 (0.06)	2 (0.02)	5 (0.26)
10/11	20	132314	110755	21559	83 (0.63)	38 (0.34)	45 (2.09)	5 (0.04)	2 (0.02)	3 (0.14)
11/12	31	213787	180742	33045	145 (0.68)	55 (0.30)	90 (2.72)	10 (0.05)	4 (0.02)	6 (0.18)
12/13	34	210069	176202	33868	162 (0.77)	54 (0.31)	108 (3.19)	11 (0.05)	2 (0.01)	9 (0.27)
13/14	39	257517	216619	40898	154 (0.60)	50 (0.23)	104 (2.54)	15 (0.06)	4 (0.02)	11 (0.27)
14/15	31	229372	195124	34247	118 (0.51)	36 (0.18)	82 (2.39)	17 (0.07)	4 (0.02)	13 (0.38)
15/16	29	208765	177506	31259	91 (0.44)	33 (0.19)	58 (1.86)	8 (0.04)	3 (0.02)	5 (0.16)

Exp; exposure, Syn; syndesmotic, ii; Injury incidence/1,000 exposure hours

Table 2 Definitions of variables used in the study

Training session	Team training that involved physical activity under the supervision of the coaching staff
Match	Competitive or friendly match against another team
Time loss injury	Any physical complaint sustained by a player that resulted from a football match or football training and led to the player being unable to take a full part in future football training or match play
Moderate injury	Injury causing 8–28 days absence
Severe injury	Injury causing >28 days absence
Re-injury	Injury of the same type and at the same site as an index injury
Injury incidence	Number of injuries per 1000 player-hours ((Σ injuries/Σ exposure-hours)×1000)
Injury burden	Number of days absence per 1000 player-hours ((Σ days absence / Σ exposure-hours)×1000)

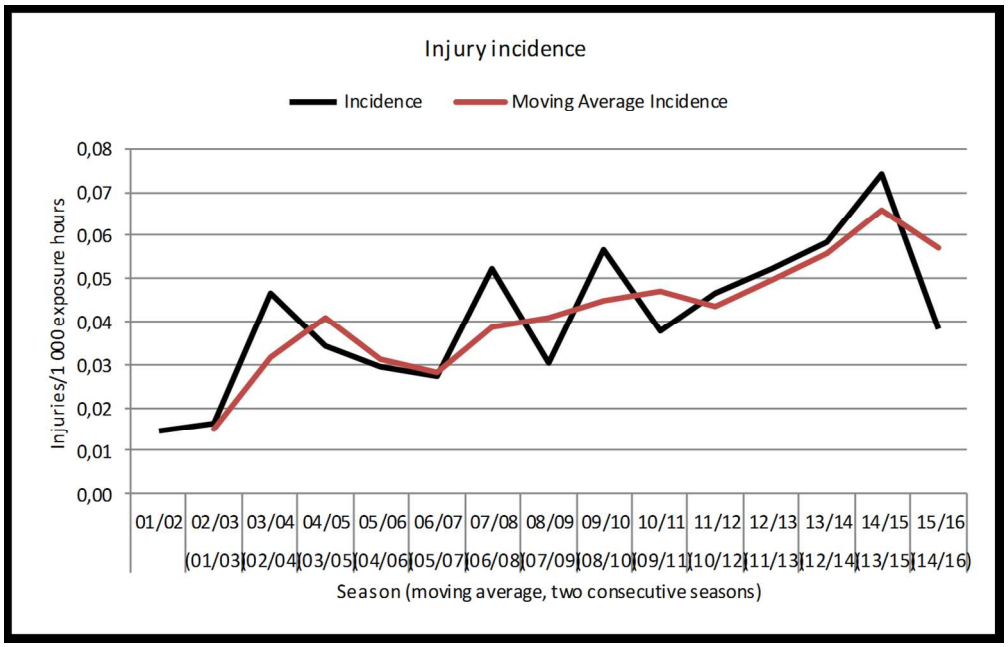

Figure 1: Seasonal variation in injury incidence of syndesmotic injuries in professional football. A significant 7.5% annual increase in isolated syndesmotic injury incidence was observed (R2=0.525, b=0.075, 95% CI 0.032 to 0.117, p=0.002) over the 15 seasons. MA, moving average;

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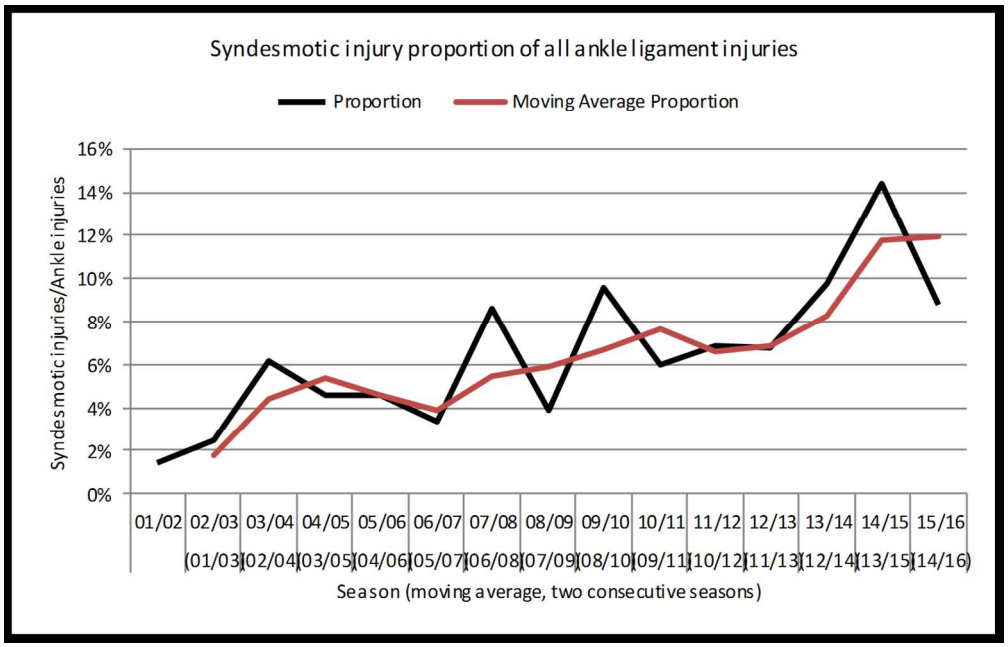

Figure 2: Seasonal variation of the proportion of syndesmotic injuries of all ankle ligament injuries in professional football. An annual 10.7% (R2=0.633, b=0.107, 95% CI 0.058 to 0.155, p<0.001) increase of the proportion of syndesmotic injuries was observed.
MA, moving average;

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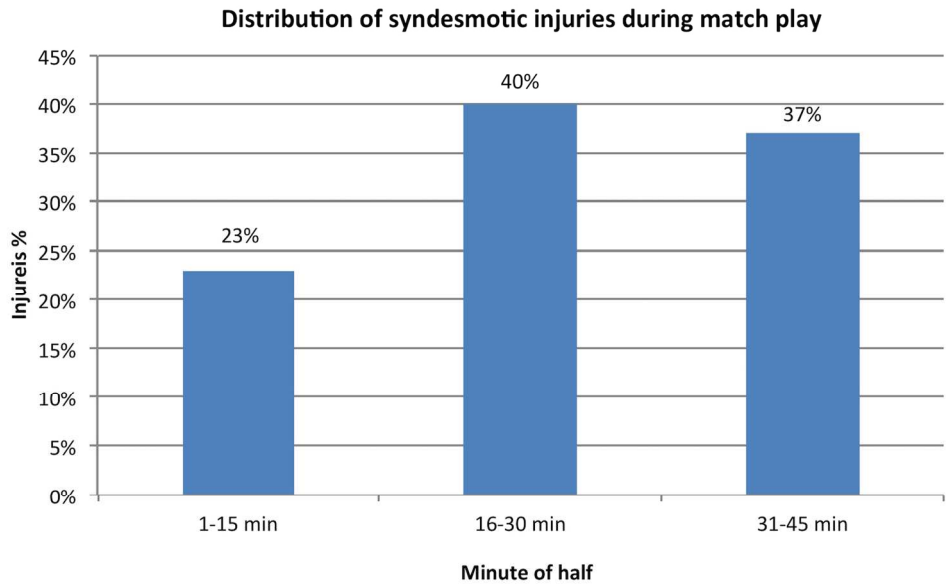

Figure 3: Distribution of syndesmotic injuries during 15 min periods of match play in professional football;

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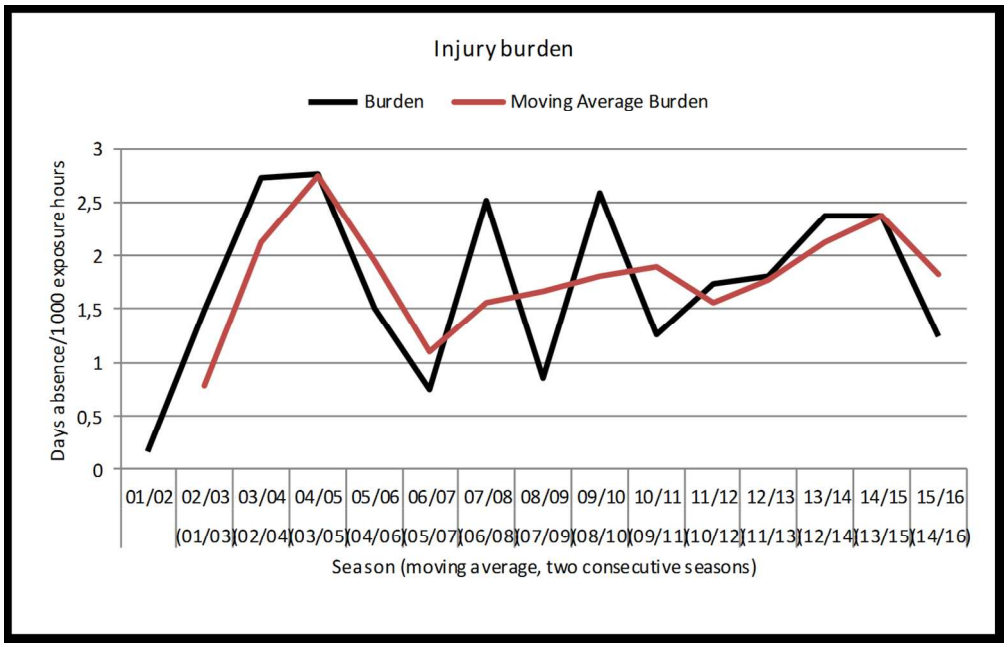

Figure 4: Seasonal variation in injury burden of syndesmotic injuries in professional football. There were no significant annual changes in injury burden (R2=0.123, b=0.058, 95% CI -0.035 to 0.151, p=0.200). Similarly, no annual change was shown when the two season moving average of injury burden was analyzed. MA, moving average;

139x88mm (300 x 300 DPI)