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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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Complete List of Authors:	Lubberts, Bart; Massachusetts General Hospital Department of Orthopaedic Surgery, D'Hooghe, Pieter Bengtsson, Håkan; DiGiovanni, Christopher Calder, James; Fortius clinic Ekstrand, Jan; Health University
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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)
<p>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.</p>	<p>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.</p>	<p>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."</p> <p>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</p>

		<p>addition, injury incidence, injury burden and syndesmotoc 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.”</p>
<p>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.</p>	<p>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.</p>	<p>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...”</p> <p>Line 329 – 330 now reads: “Fourth, we did not capture data on player medical history (i.e., previous syndesmotoc or ankle ligament injury).”</p>
<p>3. The authors stated that "In these analyses, a log-transformation of the dependent variables injury incidence, injury burden and syndesmotoc 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.</p>	<p>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.</p>	<p>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 syndesmotoc 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, $p=0.520$).”</p> <p>Line 83 – 84 now reads: “The incidence of</p>

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		<p>isolated syndesmotoc injuries in elite professional European football annually increased between 2001-16.”</p>
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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 syndesmotoc 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 syndesmotoc 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 syndesmotoc injuries (proportion of all ankle ligament injuries that were diagnosed as syndesmotoc 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 syndesmotom 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 syndesmotom 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 syndesmotom 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”

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<p>4. There are also some errors in the interpretation e.g., "A significant 7.5% annual increase in isolated syndesmotoc injury incidence was observed (R2=0.525, b=0.075, 95% CI 0.032 to 0.117, p=0.002) over the 15 seasons"</p> <p>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!</p>	<p>Once again a valid point. In the revised manuscript we have decided to not use log-transformed dependent variables.</p>	<p>Line 83 – 84 now reads: “The incidence of isolated syndesmotoc injuries in elite professional European football annually increased between 2001-16.”</p> <p>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.”</p> <p>Line 281 – 283 now reads: “Over the 15 seasons an annual increase in isolated syndesmotoc 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”</p>
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1 **Epidemiology and return to play following isolated syndesmotom injuries of the**
2 **ankle: a prospective cohort study of 3677 male professional footballers in the**
3 **UEFA Elite Club Injury Study**
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5 **Bart Lubberts, MD**

6 Research Fellow
7 Orthopaedic Foot and Ankle Service
8 Massachusetts General Hospital
9 Harvard Medical School
10 lubbertsb@gmail.com
11

12 **Pieter D'Hooghe, MD**

13 Consultant Orthopaedic Surgeon
14 Department of Orthopaedic Surgery
15 Aspetar Orthopaedic and Sports medicine Hospital
16 Aspire Zone - PO Box: 29222
17 Doha, Qatar
18 pieter.orthopedie@gmail.com
19

20 **Håkan Bengtsson**

21 Football Research Group, division of Physiotherapy
22 Department of Medicine and Health
23 Linköping University, Sweden
24 info.frg@telia.com
25

26 **Christopher W. DiGiovanni, MD**

27 Chief, Foot and Ankle Service
28 Vice Chair and Associate Professor of Orthopaedic Surgery
29 Department of Orthopaedic Surgery
30 Massachusetts General Hospital
31 Harvard Medical School
32 cwdigiovanni@partners.org
33

34 **James Calder, MD, PhD, FRCS (Tr & Orth)**

35 Consultant Orthopaedic Surgeon
36 Fortius Clinic
37 London, England
38 Visiting Professor, Imperial College London
39 James.Calder@fortiusclinic.com
40

41 **Jan Ekstrand, MD, PhD**

42 Football Research Group, division of Community Health
43 Department of Medicine and Health
44 Linköping University, Sweden
45 jan.ekstrand@telia.com

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47 **Corresponding author and requests for reprints**
48 Bart Lubberts, MD
49 Orthopaedic Foot and Ankle Service,
50 Massachusetts General Hospital - Harvard Medical School
51 55 Fruit Street,
52 Boston, Massachusetts, 02114, United States of America
53 E-mail address: lubbertsb@gmail.com

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2
3 54 **Abstract**
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8 56 **Aim**
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10 57 To determine the epidemiology of isolated syndesmotic injuries in professional football
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12 58 players.
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17 60 **Methods**
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20 61 Data from 15 consecutive seasons of European professional football between 2001 and
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22 62 2016 contributed to the dataset of this study. Match-play and training data from a total of
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24 63 3677 players from 61 teams across 17 countries have been included. Team medical staff
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26 64 recorded player exposure and time loss injuries. Injury incidence was defined as the
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28 65 number of injuries per 1000 player-hours. Injury burden was defined as number of days
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30 66 absence per 1000 player-hours. Seasonal trends for isolated syndesmotic injury incidence,
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32 67 isolated syndesmotic injury proportion of ankle ligament injuries, and isolated
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34 68 syndesmotic injury burden were analysed via linear regression.
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41 70 **Results**
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44 71 The isolated syndesmotic injury incidence was 0.05 injuries per 1000 hours of
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46 72 exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury
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48 73 incidence during match play was 13 times higher compared to during training, 0.21 (95%
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50 74 CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively. Out of the 1320 ankle
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52 75 ligament injuries registered during the 15 seasons, 94 (7%) were diagnosed as isolated
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54 76 syndesmotic injuries. An annual increase in injury incidence was observed ($R^2=0.495$,
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3 77 b=0.003, 95% CI 0.001 to 0.004, p=0.003). However, no significant annual change of
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5 78 injury burden was observed ($R^2=0.033$, b=0.032, 95% CI -0.073 to 0.138, p=0.520). 74%
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8 79 of the injuries were contact related and the mean (+/- SD) absence following an isolated
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10 80 syndesmotoc injury was 39 (+/- 28) days.
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14 82 **Conclusions**

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17 83 The incidence of isolated syndesmotoc injuries in elite professional European
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20 84 football ~~annually increased between 2001-16~~.
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27 87 **Key Words:** syndesmosis, high ankle sprain, incidence, football, epidemiology
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30 31 32 89 **What are the new findings**

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34 90 • Injury incidence during match play has increased over the past 15 seasons
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36 91 • Isolated syndesmotoc injury in football is most commonly caused by tackling
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38 92 • Average return to play after injury exceeds 5 weeks
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42 43 44 94 **How might it impact on clinical practice in the near future**

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46 95 • Our findings may assist in making football players, coaches, referees and the club
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48 96 medical staff aware of isolated syndesmotoc injury and its consequences
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51 97 • Our findings may contribute to the development of injury prevention strategies in
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53 98 football as they demonstrate that isolated syndesmotoc injuries are most
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55 99 commonly caused by player-tackling
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100 Introduction

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

110 Isolated syndesmotic injuries occur more commonly in athletes than in the general
111 population.⁵⁻¹³ Certain sports are characterised by a higher proportion of ankle
112 syndesmosis injuries; these include boot immobilised sports⁵⁻⁸ such as skiing and ice-
113 hockey, as well as collision sports such as American football, wrestling, and rugby.^{9 10 12}
114 ¹⁴

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

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123 providing important data regarding expected return to play times.¹⁶

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

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3 127 **Material and methods**
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5 128 This is a substudy of a long-term prospective cohort study evaluating men's
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8 129 professional football in Europe since 2001.¹⁷ The current study includes data from 15
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10 130 consecutive seasons of European professional football between 2001 and 2016. During
11
12 131 the study period, a total of 3677 players from 61 teams representing 17 countries have
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14 132 been included (table 1).
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20 134 *Exposure and injury registration*
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22 135 All first team players in included teams were invited to participate in the study.
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24 136 Participation was voluntary and written informed consent was obtained at the time of
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26 137 study inclusion. At the beginning of every season, teams appointed a contact person
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28 138 within each respective medical team to be responsible for collecting data and
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30 139 communicating with the study group. During the study period, all individual player
31
32 140 exposure during supervised training sessions and matches was recorded on standard
33
34 141 attendance records. In addition, all time loss injuries that occurred were registered on
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36 142 standard injury cards containing information about type of injury and circumstances of
37
38 143 the injury occasion (ie. injury mechanism, affected side, time of injury, re-injury)(table
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40 144 2). Each month, the appointed contact person reported the attendance records and injury
41
42 145 cards to the study group. All injuries were given a diagnostic code by the study group in
43
44 146 accordance with the Orchard Sports Injury Classification System (OSICS) 2.0.¹⁸ OSICS
45
46 147 2.0 codes were used to identify isolated ankle syndesmotic injuries. Athletes with
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48 148 tenderness on palpation over the anterior interosseous membrane proximal to the ankle
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50 149 joint and positive special tests ~~such as ankle external rotation~~ and syndesmosis squeeze
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3 150 test were suspected for syndesmotic injury. Uncertainty of the diagnosis was resolved
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5 151 through widening of the tibiofibular joint seen during radiographic assessment, or
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8 152 ultrasonographic or magnetic resonance imaging (MRI) evidence of rupture of
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10 153 syndesmotic ligaments without associated fibula fracture. Data collection was undertaken
11
12 154 in accordance with a previously published consensus statement regarding how to conduct
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14 155 epidemiological research in professional football.¹⁹ Methodology related to the exposure
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16 156 and injury registration has previously been described in detail.¹⁹
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22 158 *Data analysis and statistics*
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24 159 Data were analysed using SPSS (IBM SPSS Statistics for Windows, V.23.0, IBM
25
26 160 Corp, Armonk, New York, USA). Injury incidence was described as the number of
27
28 161 injuries/1000 hours of exposure, with corresponding 95% confidence intervals (CI).
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30 162 Injury incidence in training and match play were calculated and rate ratio between
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32 163 training and match play were analysed with Poisson regressions using match exposure
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34 164 hours as an offset. The proportion of match injuries occurring in different 15-minute-
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36 165 periods of match halves were compared to the expected 33% proportion, which would be
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38 166 present if injuries were evenly distributed between the different thirds, and analysed with
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40 167 Z-statistics. Injury severity was defined by the number of days of absence caused by the
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42 168 injuries and described with mean (\pm SD) and median (25th and 75th percentile). Injury
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44 169 burden was defined as number of day's absence/1000 hours of exposure. Injury burden in
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46 170 training and match play were calculated and injury burden ratio between training and
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6 174 proportion (proportion of all ankle ligament injuries that were diagnosed as syndesmotoc
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8 175 injuries) were analysed using linear regression. In these analyses injury incidence, injury
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10 176 burden and syndesmotoc injury proportion was used as dependent variables in separate
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12 177 analyses, while season was used as the independent variable in all analyses. In addition,
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14 178 injury incidence, injury burden and syndesmotoc injury proportion in match play were
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16 179 also analysed using linear regression with season included as the independent variable.
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20 180 Analyses of training injuries specifically were not performed since the number of injuries
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22 181 during training were few.

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24 182 To reduce possible effects of large temporary variations between seasons, moving
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26 183 averages (MA) of two consecutive seasons were also used as dependent variables in
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28 184 similar linear regression analyses. All analyses were two sided, and the significance level
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30 185 was set at $p < 0.05$.
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186 Results

187 *Isolated syndesmotomic injury incidence*

188 The overall isolated syndesmotomic injury incidence over the study period was 0.05
189 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3
190 seasons. The injury incidence during match play was 13 times higher compared to the
191 incidence during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02)
192 respectively (RR 12.63; 95% CI 8.12 to 19.65). A significant annual increase in isolated
193 syndesmotomic injury incidence in general ($R^2=0.495$, $b=0.003$, 95% CI 0.001 to 0.004,
194 $p=0.003$) as well as in match play ($R^2=0.354$, $b=0.013$, 95% CI 0.002 to 0.023, $p=0.019$)
195 was observed over the 15 seasons (figure 1).

196 The sensitivity analyses, using moving averages of two consecutive seasons, also
197 showed an annual increase in syndesmotomic injury incidence in general ($R^2=0.822$,
198 $b=0.003$, 95% CI 0.002 to 0.004, $p<0.001$) as well as in match play ($R^2=0.751$, $b=0.015$,
199 95% CI 0.009 to 0.020, $p<0.001$).

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201 *Isolated syndesmotomic injury proportion of all ankle ligament injuries*

202 Out of the 14 653 injuries registered during the 15 seasons 1950 (13%) affected
203 the ankle with 1320 (9%) ankle ligament injuries. ~~Out of these 1320 injuries 94 (7%)~~
204 were diagnosed as syndesmotomic injuries. An annual increase of the proportion of
205 syndesmotomic injuries (proportion of all ankle ligament injuries that were diagnosed as
206 syndesmotomic injuries) was observed ($R^2=0.601$, $b=0.006$, 95% CI 0.003 to 0.009,
207 $p=0.001$) (figure 2). The proportion of syndesmotomic injuries during match play also
208 increased annually ($R^2=0.430$, $b=0.006$, 95% CI 0.002 to 0.010, $p=0.008$).

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3 209 The sensitivity analyses, using moving averages of two consecutive seasons, also
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6 210 showed an annual increase in the proportion of syndesmotic injuries in general
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8 211 ($R^2=0.818$, $b=0.006$, 95% CI 0.004 to 0.008, $p<0.001$) and in match play ($R^2=0.758$,
9
10 212 $b=0.006$, 95% CI 0.004 to 0.009, $p<0.001$).
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15 214 *Injury patterns*

17 215 Seventy percent of the syndesmotic injuries occurred during match play and the
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20 216 remaining 30% during training. Being tackled was responsible for one third of the
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22 217 syndesmotic injuries. The remaining injuries were accounted for by: twisting/turning
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24 218 (13%), landing from a jump (10%), collisions (5%), being kicked (5%), tackling (4%),
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27 219 other (10%), and for 20% the mechanism was unknown. Seventy-four percent of the
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29 220 injuries involved contact of some kind and 54% affected the dominant leg (defined as the
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31 221 preferred kicking leg). Seven percent were considered re-injuries. No significant
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34 222 differences were found between the proportion of injuries occurring during 15-minute-
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36 223 periods of each half (0-15, 16-30, 31-45 minutes) and the 33% which would be expected
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39 224 if the injuries were evenly distributed between the different thirds of the match halves
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41 225 (figure 3).
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228 *Injury severity and absence*

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

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234 *Isolated syndesmotic injury burden*

235 A total of 3,652 days of absence due to syndesmotic injuries were reported over
236 the study period, representing an injury burden of 1.8 days absent per /1000 hours of
237 exposure. The injury burden due to match exposure was 18 (RR 18.22; 95% CI 16.86 to
238 19.68) times higher compared to training (8.8 days absent/1000 match hours versus 0.5
239 days absent per 1000 training hours). There were no significant annual changes in injury
240 burden in general ($R^2=0.033$, $b=0.032$, 95% CI -0.073 to 0.138, $p=0.520$) or in match
241 play ($R^2=0.003$, $b=0.060$, 95% CI -0.598 to 0.718, $p=0.847$).

242 Similarly, no annual change in general ($R^2=0.059$, $b=0.028$, 95% CI -0.043 to
243 0.099, $p=0.405$) or in match play ($R^2=0.005$, $b=0.050$, 95% CI -0.389 to 0.488, $p=0.809$)
244 was shown when the two-season moving average of injury burden was analysed (figure
245 4).

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3 246 **Discussion**
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5 247 The incidence figures indicate that an isolated syndesmotic injury in professional
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8 248 football is a relatively rare event. Despite this, the injury incidence during match play
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10 249 seems to have increased over the past 15 seasons. Return to play after injury took on
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13 250 average greater than 5 weeks.
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17 252 *Comparison with Other Sports*
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20 253 Isolated syndesmotic injuries are more common in collision sports and those that
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22 254 involve rigid immobilisation of the ankle in a boot.²⁰ In a cohort consisting of National
23
24 255 Collegiate Athletic Association (NCAA) American football players the incidence of
25
26 256 syndesmotic injury during games was 1.6 per 1000 athlete exposures (defined as one
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28 257 athlete participating in one practice or competition in which there was a possibility for
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30 258 athletic injury).²¹ Flik et al.⁸ collected injury data from 12 NCAA Division I ice hockey
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32 259 teams over one season and found that the game injury was 0.93 per 1000 athlete
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34 260 exposures. For rugby the injury rate per 1000 hours of exposure was 0.89 in Rugby
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36 261 Union and 0.46 in Rugby League.²² In our study, the syndesmotic injury incidence rate
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38 262 during match play over the study period was 0.21 injuries per 1000 hours of exposure.
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40 263 Accounting 90 minutes exposure for each match played, the incidence of syndesmotic
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42 264 injury during games was 0.32 per 1000 athlete exposures. Hence, the risk of incurring a
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44 265 syndesmotic injury playing football is lower compared to American football, ice hockey,
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46 266 or rugby.
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55 268 *Professional versus non-professional football players*
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3 269 Mauntel et al.¹⁵ described the epidemiology of isolated syndesmotic injuries
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6 270 among college student-athletes in 25 sports over six seasons. ~~Similarly with our findings~~
7
8 271 the injury incidence during match play was 0.34 per 1000 athlete exposures and the
9
10 272 injury incidence during training was 0.047 per 1000 athlete exposures. Compared to
11
12 273 professional players fewer injuries were caused by contact (74% among professional
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14 274 players versus 56% among non-professional players). Interestingly, the absence
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16 275 following an isolated syndesmotic injury was in 80% of the injuries less than 21 days.
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18 276 Previous studies, including ours have described an absence ranging from 30 to 62 days.²³⁻
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20 277 ²⁶ A possible explanation could be that some lateral ankle sprains may have been 
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22 278 **misdiagnosed and diagnosed as syndesmotic injuries instead.** Unfortunately, the authors
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27 279 did not describe the methods used for diagnosing the injury.
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31 *Yearly Increase in Injury Incidence*

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34 282 Over the 15 seasons an annual increase in isolated syndesmotic injury incidence
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36 283 in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per
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38 284 1.000 hours) was observed (figure 1). This might be a reflection of the fact that today's
39
40 285 health care providers have greater suspicion for the injury, or perhaps because of the
41
42 286 more frequent use of magnetic resonance imaging or diagnostic arthroscopy.^{24 27} Another
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44 287 explanation could be a general philosophical change in the way clubs attend to player
45
46 288 complaints.²⁸ Nonetheless, our data showed that being tackled caused most injuries, and
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48 289 the injury happened 13 times more frequently during match play than during a training
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50 290 session. Hence, we propose that the increase in annual injury incidence is caused by a
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53 291 more aggressive style of play during matches over the 15 years.
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5 293 *Low proportion of syndesmotic injury*

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8 294 Isolated syndesmotic injuries accounted for 7% of all ankle ligament injuries. The
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10 295 reported proportion of isolated syndesmotic injuries among overall ankle ligament
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12 296 injuries ranges from 18 to 74%.^{8 10 21 25 29-31} This variation can be explained by the fact
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14 297 that some sports have extrinsic risk factors associated with syndesmotic injury. Skiers
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16 298 and ice hockey players wear boots causing rigid immobilisation of the ankle leading to
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18 299 high-torque external rotation of the foot,^{5 8 25} and American football is often played on
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20 300 artificial turf instead of natural surfaces.^{10 21 29 31} Another plausible explanation is that an
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22 301 isolated syndesmotic injury can be frequently misdiagnosed as an ankle sprain.
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29 303 *Injury burden*

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31 304 The average absence from play following a syndesmotic injury was 39 days. This
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33 305 is in line with findings from previous studies that reported prolonged time to return to
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35 306 play after a syndesmotic injury, ranging from 30 to 62 days.²³⁻²⁶ In contrast, following
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37 307 lateral ankle sprains the absence has been reported 15 days.³² In addition, over the course
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39 308 of 15 seasons we found no change in injury burden despite the injury incidence having
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41 309 increased. Hence, the time to return to play after injury over the past 15 seasons has
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43 310 decreased. A reason for this decrease could be that recent research on treatment strategies
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45 311 and diagnosing the severity of the injury may have lead to improved outcomes.^{11 23 33-35}
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47 312 Nevertheless, to reduce the risk and consequences of this injury to a team, club medical
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49 313 staff should be conscious of whether the injury is stable or unstable since each requires
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51 314 different treatment strategies.¹¹ Appropriate management of syndesmotic injuries leads to
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3 315 an earlier return to play.²³ In addition, use of ankle braces,³⁶ referees being stricter while
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5 316 judging player tackling, and changes to game play rules - such as sliding - may help
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8 317 reducing the injury incidence rate.
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12 319 *Strengths and study limitations*

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15 320 The strength of this study is the large homogenous data set prospectively collected
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17 321 among 61 professional football teams. Having many teams working together provides
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19 322 robust data from which to draw conclusions.^{16 37} There are, however, a few limitations.
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21 323 We were not able to capture data on possible confounders and these could therefore not
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23 324 be included in our analyses. First, the injury form did not capture the examination
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25 325 findings or diagnostic tests results to classify syndesmotomic injuries beyond identifying a
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27 326 lack of fracture, or provide information on associated injuries. Second, the diagnosis was
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29 327 made by the medical staff of each football team and thus subject to the biases and
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31 328 experience of different physicians. Increasing awareness of the diagnosis of ‘syndesmosis
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33 329 injury’ may explain part of the trend to increased incidence. Third, we did not capture
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35 330 data on pitch or weather conditions at the time of injury. Fourth, we did not capture data
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37 331 on player medical history (i.e., previous syndesmotomic or ankle ligament injury). Fifth,
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39 332 there was no information available on how players were treated (i.e., conservatively or
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41 333 surgically). These data would have been useful to provide better perspective with respect
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43 334 to interpreting absentee time following the injury.
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3 338 *Conclusion*
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5 339 Our findings indicate a significant increase in the incidence of isolated
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8 340 syndesmotic injuries in professional football players. We speculate this is likely caused
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10 341 by more aggressive playing style during matches. The average return to play time
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12 342 following injury exceeded 5 weeks, and there was no change found in injury burden over
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14
15 343 15 seasons. We recommend club medical staff to be conscious of the nature of the injury
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17 344 to reduce the consequences of such injuries to a team. ~~In addition, intensifying~~
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20 345 ~~preventative work can help reducing the injury incidence rate.~~ 
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3 346 **Competing interests**

4 347 There were no relationships/conditions/circumstances that present a potential conflict of
5 348 interest

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7 349
8 350 **Authors' contributions**

9 351 All authors were responsible for the conception and design of the study. HB and JE have
10 352 been involved in the data collection over the study period. HB conducted the analyses,
11 353 which were planned and checked with BL, and PD. All authors contributed to the
12 354 interpretation of the findings. BL wrote the first draft of the paper, which was critically
13 355 revised by PD, HB, CWD, JC and JE. The final manuscript has been approved by all
14 356 authors.

15 357

16 357
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25 365 the Swedish National Centre for Research in Sports.

26 366

27 366
28 367 **Ethical approval information:**

29 368 The study design was approved by the UEFA Medical Committee and the UEFA
30 369 Football Development Division.

31 370

32 370
33 371 **Data sharing statement:**

34 372 Due to confidentiality reasons there is no data that can be shared

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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*

- 1
2
3 417 2017:363546517701428. doi: 10.1177/0363546517701428 [published Online
4 418 First: 2017/04/20]
5
6 419 16. Ekstrand J. Preventing injuries in professional football: thinking bigger and working
7 420 together. *Br J Sports Med* 2016;50(12):709-10. doi: 10.1136/bjsports-2016-
8 421 096333 [published Online First: 2016/04/29]
9 422 17. Walden M, Hagglund M, Ekstrand J. UEFA Champions League study: a prospective
10 423 study of injuries in professional football during the 2001-2002 season. *Br J Sports*
11 424 *Med* 2005;39(8):542-6. doi: 10.1136/bjism.2004.014571 [published Online First:
12 425 2005/07/28]
13
14 426 18. Orchard J. Orchard Sports Injury Classification System (OSICS). *Sports health*
15 427 1993;11:39- 41.
16 428 19. Hagglund M, Walden M, Bahr R, et al. Methods for epidemiological study of injuries
17 429 to professional football players: developing the UEFA model. *Br J Sports Med*
18 430 2005;39(6):340-6. doi: 10.1136/bjism.2005.018267 [published Online First:
19 431 2005/05/25]
20 432 20. Williams GN, Jones MH, Amendola A. Syndesmotic ankle sprains in athletes. *Am J*
21 433 *Sports Med* 2007;35(7):1197-207. doi: 10.1177/0363546507302545 [published
22 434 Online First: 2007/05/24]
23
24 435 21. Hunt KJ, George E, Harris AH, et al. Epidemiology of syndesmosis injuries in
25 436 intercollegiate football: incidence and risk factors from National Collegiate
26 437 Athletic Association injury surveillance system data from 2004-2005 to 2008-
27 438 2009. *Clinical journal of sport medicine : official journal of the Canadian*
28 439 *Academy of Sport Medicine* 2013;23(4):278-82. doi:
29 440 10.1097/JSM.0b013e31827ee829 [published Online First: 2013/01/24]
30 441 22. Sman AD, Hiller CE, Rae K, et al. Predictive factors for ankle syndesmosis injury in
31 442 football players: a prospective study. *Journal of science and medicine in sport*
32 443 2014;17(6):586-90. doi: 10.1016/j.jsams.2013.12.009 [published Online First:
33 444 2014/01/28]
34
35 445 23. Calder JD, Bamford R, Petrie A, et al. Stable Versus Unstable Grade II High Ankle
36 446 Sprains: A Prospective Study Predicting the Need for Surgical Stabilization and
37 447 Time to Return to Sports. *Arthroscopy* 2015 doi: 10.1016/j.arthro.2015.10.003
38 448 [published Online First: 2016/01/05]
39 449 24. Howard DR, Rubin DA, Hillen TJ, et al. Magnetic resonance imaging as a predictor
40 450 of return to play following syndesmosis (high) ankle sprains in professional
41 451 football players. *Sports health* 2012;4(6):535-43. doi:
42 452 10.1177/1941738112462531 [published Online First: 2013/11/02]
43 453 25. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in national
44 454 hockey league players. *Am J Sports Med* 2004;32(8):1941-5. [published Online
45 455 First: 2004/12/02]
46 456 26. Sman AD, Hiller CE, Rae K, et al. Prognosis of ankle syndesmosis injury. *Medicine*
47 457 *and science in sports and exercise* 2014;46(4):671-7. doi:
48 458 10.1249/mss.000000000000151 [published Online First: 2013/09/05]
49 459 27. Takao M, Ochi M, Oae K, et al. Diagnosis of a tear of the tibiofibular syndesmosis.
50 460 The role of arthroscopy of the ankle. *The Journal of bone and joint surgery*
51 461 *British volume* 2003;85(3):324-9. [published Online First: 2003/05/06]
52
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3 462 28. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and
4 463 player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of
5 464 teams' head medical officers. *Br J Sports Med* 2016;50(12):725-30. doi:
6 465 10.1136/bjsports-2015-095259 [published Online First: 2016/01/23]
7
8 466 29. Boytim MJ, Fischer DA, Neumann L. Syndesmotic ankle sprains. *American Journal*
9 467 *of Sports Medicine* 1991;19(3):294-98.
10 468 30. Roemer FW, Jomaah N, Niu J, et al. Ligamentous Injuries and the Risk of Associated
11 469 Tissue Damage in Acute Ankle Sprains in Athletes: A Cross-sectional MRI
12 470 Study. *Am J Sports Med* 2014;42(7):1549-57. doi: 10.1177/0363546514529643
13 471 31. Osbahr DC, Drakos MC, O'Loughlin PF, et al. Syndesmosis and lateral ankle sprains
14 472 in the National Football League. *Orthopedics* 2013;36(11):e1378-e84.
15 473 32. Walden M, Hagglund M, Ekstrand J. Time-trends and circumstances surrounding
16 474 ankle injuries in men's professional football: an 11-year follow-up of the UEFA
17 475 Champions League injury study. *Br J Sports Med* 2013;47(12):748-53. doi:
18 476 10.1136/bjsports-2013-092223 [published Online First: 2013/07/03]
19 477 33. Westermann RW, Rungprai C, Goetz JE, et al. The effect of suture-button fixation on
20 478 simulated syndesmotic malreduction: a cadaveric study. *The Journal of bone and*
21 479 *joint surgery American volume* 2014;96(20):1732-8. doi: 10.2106/jbjs.n.00198
22 480 [published Online First: 2014/10/17]
23 481 34. Forschner PF, Beitzel K, Imhoff AB, et al. Five-Year Outcomes After Treatment for
24 482 Acute Instability of the Tibiofibular Syndesmosis Using a Suture-Button Fixation
25 483 System. *Orthopaedic journal of sports medicine* 2017;5(4):2325967117702854.
26 484 doi: 10.1177/2325967117702854 [published Online First: 2017/05/17]
27 485 35. Ryan PM, Rodriguez RM. Outcomes and Return to Activity After Operative Repair
28 486 of Chronic Latent Syndesmotic Instability. *Foot & ankle international*
29 487 2016;37(2):192-7. doi: 10.1177/1071100715606488 [published Online First:
30 488 2015/09/20]
31 489 36. McGuine TA, Hetzel S, Wilson J, et al. The effect of lace-up ankle braces on injury
32 490 rates in high school football players. *Am J Sports Med* 2012;40(1):49-57. doi:
33 491 10.1177/0363546511422332 [published Online First: 2011/09/20]
34 492 37. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in
35 493 professional football: the UEFA injury study. *Br J Sports Med* 2011;45(7):553-8.
36 494 doi: 10.1136/bjism.2009.060582 [published Online First: 2009/06/26]

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3 496 **Figure legends**

4
5 497 **Figure 1:** Seasonal variation in injury incidence of syndesmotoc injuries in professional
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football. *MA*, moving average;

500 **Figure 2:** Seasonal variation of the proportion of syndesmotoc injuries of all ankle
501 ligament injuries in professional football.

502 *MA*, moving average;

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504 **Figure 3:** Distribution of syndesmotoc injuries during 15 min periods of match play in
505 professional football;

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

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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; syndesmotie, ii; Injury incidence/1,000 exposure hours

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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 ($(\sum \text{injuries} / \sum \text{exposure-hours}) \times 1000$)
Injury burden	Number of days absence per 1000 player-hours ($(\sum \text{days absence} / \sum \text{exposure-hours}) \times 1000$)

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1 **Epidemiology and return to play following isolated syndesmotic injuries of the**
2 **ankle: a prospective cohort study of 3677 male professional footballers in the**
3 **UEFA Elite Club Injury Study**
4

5 **Bart Lubberts, MD**

6 Research Fellow
7 Orthopaedic Foot and Ankle Service
8 Massachusetts General Hospital
9 Harvard Medical School
10 lubbertsb@gmail.com
11

12 **Pieter D'Hooghe, MD**

13 Consultant Orthopaedic Surgeon
14 Department of Orthopaedic Surgery
15 Aspetar Orthopaedic and Sports medicine Hospital
16 Aspire Zone - PO Box: 29222
17 Doha, Qatar
18 pieter.orthopedie@gmail.com
19

20 **Håkan Bengtsson**

21 Football Research Group, division of Physiotherapy
22 Department of Medicine and Health
23 Linköping University, Sweden
24 info.frg@telia.com
25

26 **Christopher W. DiGiovanni, MD**

27 Chief, Foot and Ankle Service
28 Vice Chair and Associate Professor of Orthopaedic Surgery
29 Department of Orthopaedic Surgery
30 Massachusetts General Hospital
31 Harvard Medical School
32 cwdigiovanni@partners.org
33

34 **James Calder, MD, PhD, FRCS (Tr & Orth)**

35 Consultant Orthopaedic Surgeon
36 Fortius Clinic
37 London, England
38 Visiting Professor, Imperial College London
39 James.Calder@fortiusclinic.com
40

41 **Jan Ekstrand, MD, PhD**

42 Football Research Group, division of Community Health
43 Department of Medicine and Health
44 Linköping University, Sweden
45 jan.ekstrand@telia.com

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47 **Corresponding author and requests for reprints**
48 Bart Lubberts, MD
49 Orthopaedic Foot and Ankle Service,
50 Massachusetts General Hospital - Harvard Medical School
51 55 Fruit Street,
52 Boston, Massachusetts, 02114, United States of America
53 E-mail address: lubbertsb@gmail.com

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2
3 54 **Abstract**
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8 56 **Aim**
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10 57 To determine the epidemiology of isolated syndesmotic injuries in professional football
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12 58 players.
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17 60 **Methods**
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20 61 Data from 15 consecutive seasons of European professional football between 2001 and
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22 62 2016 contributed to the dataset of this study. Match-play and training data from a total of
23
24 63 3677 players from 61 teams across 17 countries have been included. Team medical staff
25
26 64 recorded player exposure and time loss injuries. Injury incidence was defined as the
27
28 65 number of injuries per 1000 player-hours. Injury burden was defined as number of days
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30 66 absence per 1000 player-hours. Seasonal trends for isolated syndesmotic injury incidence,
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32 67 isolated syndesmotic injury proportion of ankle ligament injuries, and isolated
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34 68 syndesmotic injury burden were analysed via linear regression.
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41 70 **Results**
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43
44 71 The isolated syndesmotic injury incidence was 0.05 injuries per 1000 hours of
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46 72 exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3 seasons. The injury
47
48 73 incidence during match play was 13 times higher compared to during training, 0.21 (95%
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50 74 CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02) respectively. Out of the 1320 ankle
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52 75 ligament injuries registered during the 15 seasons 94 (7%) were diagnosed as isolated
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54 76 syndesmotic injuries. An annual increase in injury incidence was observed ($R^2=0.495$,
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3 77 $b=0.003$, 95% CI 0.001 to 0.004, $p=0.003$). However, no significant annual change of
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6 78 injury burden was observed ($R^2=0.033$, $b=0.032$, 95% CI -0.073 to 0.138, $p=0.520$). 74%
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8 79 of the injuries were contact related and the mean (+/- SD) absence following an isolated
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10 80 syndesmotoc injury was 39 (+/- 28) days.
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15 82 **Conclusions**

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17 83 The incidence of isolated syndesmotoc injuries in elite professional European
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20 84 football annually increased between 2001-16.
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27 87 **Key Words:** syndesmosis, high ankle sprain, incidence, football, epidemiology
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32 89 **What are the new findings**

- 33
34 90 • Injury incidence during match play has increased over the past 15 seasons
35
36 91 • Isolated syndesmotoc injury in football is most commonly caused by tackling
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39 92 • Average return to play after injury exceeds 5 weeks
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44 94 **How might it impact on clinical practice in the near future**

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46 95 • Our findings may assist in making football players, coaches, referees and the club
47
48 96 medical staff aware of isolated syndesmotoc injury and its consequences
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51 97 • Our findings may contribute to the development of injury prevention strategies in
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53 98 football as they demonstrate that isolated syndesmotoc injuries are most
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56 99 commonly caused by player-tackling
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100 Introduction

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

110 Isolated syndesmotic injuries occur more commonly in athletes than in the general
111 population.⁵⁻¹³ Certain sports are characterised by a higher proportion of ankle
112 syndesmosis injuries; these include boot immobilised sports⁵⁻⁸ such as skiing and ice-
113 hockey, as well as collision sports such as American football, wrestling, and rugby.^{9 10 12}
114¹⁴

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

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123 providing important data regarding expected return to play times.¹⁶

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

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3 127 **Material and methods**
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5 128 This is a substudy of a long-term prospective cohort study evaluating men's
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8 129 professional football in Europe since 2001.¹⁷ The current study includes data from 15
9
10 130 consecutive seasons of European professional football between 2001 and 2016. During
11
12 131 the study period, a total of 3677 players from 61 teams representing 17 countries have
13
14 132 been included (table 1).
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20 134 *Exposure and injury registration*
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22 135 All first team players in included teams were invited to participate in the study.
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24 136 Participation was voluntary and written informed consent was obtained at the time of
25
26 137 study inclusion. At the beginning of every season, teams appointed a contact person
27
28 138 within each respective medical team to be responsible for collecting data and
29
30 139 communicating with the study group. During the study period, all individual player
31
32 140 exposure during supervised training sessions and matches was recorded on standard
33
34 141 attendance records. In addition, all time loss injuries that occurred were registered on
35
36 142 standard injury cards containing information about type of injury and circumstances of
37
38 143 the injury occasion (ie. injury mechanism, affected side, time of injury, re-injury)(table
39
40 144 2). Each month, the appointed contact person reported the attendance records and injury
41
42 145 cards to the study group. All injuries were given a diagnostic code by the study group in
43
44 146 accordance with the Orchard Sports Injury Classification System (OSICS) 2.0.¹⁸ OSICS
45
46 147 2.0 codes were used to identify isolated ankle syndesmotom injuries. Athletes with
47
48 148 tenderness on palpation over the anterior interosseous membrane proximal to the ankle
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50 149 joint and positive special tests such as ankle external, rotation and syndesmosis squeeze
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3 150 test were suspected for syndesmotic injury. Uncertainty of the diagnosis was resolved
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5 151 through widening of the tibiofibular joint seen during radiographic assessment, or
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8 152 ultrasonographic or magnetic resonance imaging (MRI) evidence of rupture of
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10 153 syndesmotic ligaments without associated fibula fracture. Data collection was undertaken
11
12 154 in accordance with a previously published consensus statement regarding how to conduct
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14 155 epidemiological research in professional football.¹⁹ Methodology related to the exposure
15
16 156 and injury registration has previously been described in detail.¹⁹
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22 158 *Data analysis and statistics*
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24 159 Data were analysed using SPSS (IBM SPSS Statistics for Windows, V.23.0, IBM
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26 160 Corp, Armonk, New York, USA). Injury incidence was described as the number of
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28 161 injuries/1000 hours of exposure, with corresponding 95% confidence intervals (CI).
29
30 162 Injury incidence in training and match play were calculated and rate ratio between
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32 163 training and match play were analysed with Poisson regressions using match exposure
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34 164 hours as an offset. The proportion of match injuries occurring in different 15-minute-
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36 165 periods of match halves were compared to the expected 33% proportion, which would be
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38 166 present if injuries were evenly distributed between the different thirds, and analysed with
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40 167 Z-statistics. Injury severity was defined by the number of days of absence caused by the
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42 168 injuries and described with mean (\pm SD) and median (25th and 75th percentile). Injury
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44 169 burden was defined as number of day's absence/1000 hours of exposure. Injury burden in
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46 170 training and match play were calculated and injury burden ratio between training and
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48 171 match play were analysed with Poisson regressions using match exposure hours as an
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50 172 offset.
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3 173 The annual changes in injury incidence, injury burden, and syndesmotoc injury
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6 174 proportion (proportion of all ankle ligament injuries that were diagnosed as syndesmotoc
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8 175 injuries) were analysed using linear regression. In these analyses injury incidence, injury
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10 176 burden and syndesmotoc injury proportion was used as dependent variables in separate
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12 177 analyses, while season was used as the independent variable in all analyses. In addition,
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14 178 injury incidence, injury burden and syndesmotoc injury proportion in match play were
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16 179 also analysed using linear regression with season included as the independent variable.
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20 180 Analyses of training injuries specifically were not performed since the number of injuries
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22 181 during training were few.

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25 182 To reduce possible effects of large temporary variations between seasons, moving
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27 183 averages (MA) of two consecutive seasons were also used as dependent variables in
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29 184 similar linear regression analyses. All analyses were two sided, and the significance level
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31 185 was set at $p < 0.05$.

186 Results

187 *Isolated syndesmotomic injury incidence*

188 The overall isolated syndesmotomic injury incidence over the study period was 0.05
189 injuries per 1000 hours of exposure (95% CI 0.04 to 0.06) or 1 injury per team every 3
190 seasons. The injury incidence during match play was 13 times higher compared to the
191 incidence during training, 0.21 (95% CI 0.16 to 0.26) and 0.02 (95% CI 0.01 to 0.02)
192 respectively (RR 12.63; 95% CI 8.12 to 19.65). A significant annual increase in isolated
193 syndesmotomic injury incidence in general ($R^2=0.495$, $b=0.003$, 95% CI 0.001 to 0.004,
194 $p=0.003$) as well as in match play ($R^2=0.354$, $b=0.013$, 95% CI 0.002 to 0.023, $p=0.019$)
195 was observed over the 15 seasons (figure 1).

196 The sensitivity analyses, using moving averages of two consecutive seasons, also
197 showed an annual increase in syndesmotomic injury incidence in general ($R^2=0.822$,
198 $b=0.003$, 95% CI 0.002 to 0.004, $p<0.001$) as well as in match play ($R^2=0.751$, $b=0.015$,
199 95% CI 0.009 to 0.020, $p<0.001$).

201 *Isolated syndesmotomic injury proportion of all ankle ligament injuries*

202 Out of the 14 653 injuries registered during the 15 seasons 1950 (13%) affected
203 the ankle with 1320 (9%) ankle ligament injuries. Out of these 1320 injuries 94 (7%)
204 were diagnosed as syndesmotomic injuries. An annual increase of the proportion of
205 syndesmotomic injuries (proportion of all ankle ligament injuries that were diagnosed as
206 syndesmotomic injuries) was observed ($R^2=0.601$, $b=0.006$, 95% CI 0.003 to 0.009,
207 $p=0.001$) (figure 2). The proportion of syndesmotomic injuries during match play also
208 increased annually ($R^2=0.430$, $b=0.006$, 95% CI 0.002 to 0.010, $p=0.008$).

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3 209 The sensitivity analyses, using moving averages of two consecutive seasons, also
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5 210 showed an annual increase in the proportion of syndesmotic injuries in general
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8 211 ($R^2=0.818$, $b=0.006$, 95% CI 0.004 to 0.008, $p<0.001$) and in match play ($R^2=0.758$,
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10 212 $b=0.006$, 95% CI 0.004 to 0.009, $p<0.001$).
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14 214 *Injury patterns*

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17 215 Seventy percent of the syndesmotic injuries occurred during match play and the
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20 216 remaining 30% during training. Being tackled was responsible for one third of the
21
22 217 syndesmotic injuries. The remaining injuries were accounted for by: twisting/turning
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24 218 (13%), landing from a jump (10%), collisions (5%), being kicked (5%), tackling (4%),
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27 219 other (10%), and for 20% the mechanism was unknown. Seventy-four percent of the
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29 220 injuries involved contact of some kind and 54% affected the dominant leg (defined as the
30
31 221 preferred kicking leg). Seven percent were considered re-injuries. No significant
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34 222 differences were found between the proportion of injuries occurring during 15-minute-
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36 223 periods of each half (0-15, 16-30, 31-45 minutes) and the 33% which would be expected
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39 224 if the injuries were evenly distributed between the different thirds of the match halves
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41 225 (figure 3).
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228 *Injury severity and absence*

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

233

234 *Isolated syndesmotic injury burden*

235 A total of 3,652 days of absence due to syndesmotic injuries were reported over
236 the study period, representing an injury burden of 1.8 days absent per /1000 hours of
237 exposure. The injury burden due to match exposure was 18 (RR 18.22; 95% CI 16.86 to
238 19.68) times higher compared to training (8.8 days absent/1000 match hours versus 0.5
239 days absent per 1000 training hours). There were no significant annual changes in injury
240 burden in general ($R^2=0.033$, $b=0.032$, 95% CI -0.073 to 0.138, $p=0.520$) or in match
241 play ($R^2=0.003$, $b=0.060$, 95% CI -0.598 to 0.718, $p=0.847$).

242 Similarly, no annual change in general ($R^2=0.059$, $b=0.028$, 95% CI -0.043 to
243 0.099, $p=0.405$) or in match play ($R^2=0.005$, $b=0.050$, 95% CI -0.389 to 0.488, $p=0.809$)
244 was shown when the two-season moving average of injury burden was analysed (figure
245 4).

246 Discussion

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

251

252 *Comparison with Other Sports*

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

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268 *Professional versus non-professional football players*

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3 269 Mauntel et al.¹⁵ described the epidemiology of isolated syndesmotic injuries
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6 270 among college student-athletes in 25 sports over six seasons. Similarly with our findings
7
8 271 the injury incidence during match play was 0.34 per 1000 athlete exposures and the
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10 272 injury incidence during training was 0.047 per 1000 athlete exposures. Compared to
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12 273 professional players fewer injuries were caused by contact (74% among professional
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14 274 players versus 56% among non-professional players). Interestingly, the absence
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16 275 following an isolated syndesmotic injury was in 80% of the injuries less than 21 days.
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18 276 Previous studies, including ours have described an absence ranging from 30 to 62 days.²³⁻
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20 277 ²⁶ A possible explanation could be that some lateral ankle sprains may have been
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22 278 misdiagnosed and diagnosed as syndesmotic injuries instead. Unfortunately, the authors
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24 279 did not describe the methods used for diagnosing the injury.
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31 *Yearly Increase in Injury Incidence*

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34 282 Over the 15 seasons an annual increase in isolated syndesmotic injury incidence
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36 283 in general (0.003 injuries per 1.000 hours) as well as in match play (0.013 injuries per
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38 284 1.000 hours) was observed (figure 1). This might be a reflection of the fact that today's
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40 285 health care providers have greater suspicion for the injury, or perhaps because of the
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42 286 more frequent use of magnetic resonance imaging or diagnostic arthroscopy.^{24 27} Another
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44 287 explanation could be a general philosophical change in the way clubs attend to player
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46 288 complaints.²⁸ Nonetheless, our data showed that being tackled caused most injuries, and
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48 289 the injury happened 13 times more frequently during match play than during a training
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50 290 session. Hence, we propose that the increase in annual injury incidence is caused by a
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53 291 more aggressive style of play during matches over the 15 years.
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5 293 *Low proportion of syndesmotic injury*

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8 294 Isolated syndesmotic injuries accounted for 7% of all ankle ligament injuries. The
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10 295 reported proportion of isolated syndesmotic injuries among overall ankle ligament
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12 296 injuries ranges from 18 to 74%.^{8 10 21 25 29-31} This variation can be explained by the fact
13
14 297 that some sports have extrinsic risk factors associated with syndesmotic injury. Skiers
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16 298 and ice hockey players wear boots causing rigid immobilisation of the ankle leading to
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18 299 high-torque external rotation of the foot,^{5 8 25} and American football is often played on
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20 300 artificial turf instead of natural surfaces.^{10 21 29 31} Another plausible explanation is that an
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22 301 isolated syndesmotic injury can be frequently misdiagnosed as an ankle sprain.
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29 303 *Injury burden*

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31 304 The average absence from play following a syndesmotic injury was 39 days. This
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33 305 is in line with findings from previous studies that reported prolonged time to return to
34
35 306 play after a syndesmotic injury, ranging from 30 to 62 days.²³⁻²⁶ In contrast, following
36
37 307 lateral ankle sprains the absence has been reported 15 days.³² In addition, over the course
38
39 308 of 15 seasons we found no change in injury burden despite the injury incidence having
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41 309 increased. Hence, the time to return to play after injury over the past 15 seasons has
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43 310 decreased. A reason for this decrease could be that recent research on treatment strategies
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45 311 and diagnosing the severity of the injury may have lead to improved outcomes.^{11 23 33-35}
46
47 312 Nevertheless, to reduce the risk and consequences of this injury to a team, club medical
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49 313 staff should be conscious of whether the injury is stable or unstable since each requires
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51 314 different treatment strategies.¹¹ Appropriate management of syndesmotic injuries leads to
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3 315 an earlier return to play.²³ In addition, use of ankle braces,³⁶ referees being stricter while
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5 316 judging player tackling, and changes to game play rules - such as sliding - may help
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8 317 reducing the injury incidence rate.
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13 319 *Strengths and study limitations*

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15 320 The strength of this study is the large homogenous data set prospectively collected
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17 321 among 61 professional football teams. Having many teams working together provides
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20 322 robust data from which to draw conclusions.^{16 37} There are, however, a few limitations.

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22 323 We were not able to capture data on possible confounders and these could therefore not

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24 324 be included in our analyses. First, the injury form did not capture the examination

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26 325 findings or diagnostic tests results to classify syndesmotom injuries beyond identifying a

27
28 326 lack of fracture, or provide information on associated injuries. Second, the diagnosis was

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30 327 made by the medical staff of each football team and thus subject to the biases and

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32 328 experience of different physicians. Increasing awareness of the diagnosis of 'syndesmosis

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34 329 injury' may explain part of the trend to increased incidence. Third, we did not capture

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36 330 data on pitch or weather conditions at the time of injury. Fourth, we did not capture data

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38 331 on player medical history (i.e., previous syndesmotom or ankle ligament injury). Fifth,

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40 332 there was no information available on how players were treated (i.e., conservatively or

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42 333 surgically). These data would have been useful to provide better perspective with respect

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44 334 to interpreting absentee time following the injury.
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3 338 *Conclusion*
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5 339 Our findings indicate a significant increase in the incidence of isolated
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8 340 syndesmotoc injuries in professional football players. We speculate this is likely caused
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10 341 by more aggressive playing style during matches. The average return to play time
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12 342 following injury exceeded 5 weeks, and there was no change found in injury burden over
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14 343 15 seasons. We recommend club medical staff to be conscious of the nature of the injury
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16 344 to reduce the consequences of such injuries to a team. In addition, intensifying
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18 345 preventative work can help reducing the injury incidence rate.
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3 346 **Competing interests**

4 347 There were no relationships/conditions/circumstances that present a potential conflict of
5 348 interest

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8 350 **Authors' contributions**

9 351 All authors were responsible for the conception and design of the study. HB and JE have
10 352 been involved in the data collection over the study period. HB conducted the analyses,
11 353 which were planned and checked with BL, and PD. All authors contributed to the
12 354 interpretation of the findings. BL wrote the first draft of the paper, which was critically
13 355 revised by PD, HB, CWD, JC and JE. The final manuscript has been approved by all
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28 367 **Ethical approval information:**

29 368 The study design was approved by the UEFA Medical Committee and the UEFA
30 369 Football Development Division.

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33 371 **Data sharing statement:**

34 372 Due to confidentiality reasons there is no data that can be shared

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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*

- 1
2
3 417 2017:363546517701428. doi: 10.1177/0363546517701428 [published Online
4 418 First: 2017/04/20]
5
6 419 16. Ekstrand J. Preventing injuries in professional football: thinking bigger and working
7 420 together. *Br J Sports Med* 2016;50(12):709-10. doi: 10.1136/bjsports-2016-
8 421 096333 [published Online First: 2016/04/29]
9 422 17. Walden M, Hagglund M, Ekstrand J. UEFA Champions League study: a prospective
10 423 study of injuries in professional football during the 2001-2002 season. *Br J Sports*
11 424 *Med* 2005;39(8):542-6. doi: 10.1136/bjism.2004.014571 [published Online First:
12 425 2005/07/28]
13
14 426 18. Orchard J. Orchard Sports Injury Classification System (OSICS). *Sports health*
15 427 1993;11:39- 41.
16 428 19. Hagglund M, Walden M, Bahr R, et al. Methods for epidemiological study of injuries
17 429 to professional football players: developing the UEFA model. *Br J Sports Med*
18 430 2005;39(6):340-6. doi: 10.1136/bjism.2005.018267 [published Online First:
19 431 2005/05/25]
20 432 20. Williams GN, Jones MH, Amendola A. Syndesmotomic ankle sprains in athletes. *Am J*
21 433 *Sports Med* 2007;35(7):1197-207. doi: 10.1177/0363546507302545 [published
22 434 Online First: 2007/05/24]
23
24 435 21. Hunt KJ, George E, Harris AH, et al. Epidemiology of syndesmosis injuries in
25 436 intercollegiate football: incidence and risk factors from National Collegiate
26 437 Athletic Association injury surveillance system data from 2004-2005 to 2008-
27 438 2009. *Clinical journal of sport medicine : official journal of the Canadian*
28 439 *Academy of Sport Medicine* 2013;23(4):278-82. doi:
29 440 10.1097/JSM.0b013e31827ee829 [published Online First: 2013/01/24]
30
31 441 22. Sman AD, Hiller CE, Rae K, et al. Predictive factors for ankle syndesmosis injury in
32 442 football players: a prospective study. *Journal of science and medicine in sport*
33 443 2014;17(6):586-90. doi: 10.1016/j.jsams.2013.12.009 [published Online First:
34 444 2014/01/28]
35
36 445 23. Calder JD, Bamford R, Petrie A, et al. Stable Versus Unstable Grade II High Ankle
37 446 Sprains: A Prospective Study Predicting the Need for Surgical Stabilization and
38 447 Time to Return to Sports. *Arthroscopy* 2015 doi: 10.1016/j.arthro.2015.10.003
39 448 [published Online First: 2016/01/05]
40
41 449 24. Howard DR, Rubin DA, Hillen TJ, et al. Magnetic resonance imaging as a predictor
42 450 of return to play following syndesmosis (high) ankle sprains in professional
43 451 football players. *Sports health* 2012;4(6):535-43. doi:
44 452 10.1177/1941738112462531 [published Online First: 2013/11/02]
45
46 453 25. Wright RW, Barile RJ, Surprenant DA, et al. Ankle syndesmosis sprains in national
47 454 hockey league players. *Am J Sports Med* 2004;32(8):1941-5. [published Online
48 455 First: 2004/12/02]
49
50 456 26. Sman AD, Hiller CE, Rae K, et al. Prognosis of ankle syndesmosis injury. *Medicine*
51 457 *and science in sports and exercise* 2014;46(4):671-7. doi:
52 458 10.1249/mss.000000000000151 [published Online First: 2013/09/05]
53 459 27. Takao M, Ochi M, Oae K, et al. Diagnosis of a tear of the tibiofibular syndesmosis.
54 460 The role of arthroscopy of the ankle. *The Journal of bone and joint surgery*
55 461 *British volume* 2003;85(3):324-9. [published Online First: 2003/05/06]
56
57
58
59
60

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2
3 462 28. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and
4 463 player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of
5 464 teams' head medical officers. *Br J Sports Med* 2016;50(12):725-30. doi:
6 465 10.1136/bjsports-2015-095259 [published Online First: 2016/01/23]
7
8 466 29. Boytim MJ, Fischer DA, Neumann L. Syndesmotic ankle sprains. *American Journal*
9 467 *of Sports Medicine* 1991;19(3):294-98.
10 468 30. Roemer FW, Jomaah N, Niu J, et al. Ligamentous Injuries and the Risk of Associated
11 469 Tissue Damage in Acute Ankle Sprains in Athletes: A Cross-sectional MRI
12 470 Study. *Am J Sports Med* 2014;42(7):1549-57. doi: 10.1177/0363546514529643
13 471 31. Osbahr DC, Drakos MC, O'Loughlin PF, et al. Syndesmosis and lateral ankle sprains
14 472 in the National Football League. *Orthopedics* 2013;36(11):e1378-e84.
15 473 32. Walden M, Hagglund M, Ekstrand J. Time-trends and circumstances surrounding
16 474 ankle injuries in men's professional football: an 11-year follow-up of the UEFA
17 475 Champions League injury study. *Br J Sports Med* 2013;47(12):748-53. doi:
18 476 10.1136/bjsports-2013-092223 [published Online First: 2013/07/03]
19 477 33. Westermann RW, Rungprai C, Goetz JE, et al. The effect of suture-button fixation on
20 478 simulated syndesmotic malreduction: a cadaveric study. *The Journal of bone and*
21 479 *joint surgery American volume* 2014;96(20):1732-8. doi: 10.2106/jbjs.n.00198
22 480 [published Online First: 2014/10/17]
23 481 34. Forschner PF, Beitzel K, Imhoff AB, et al. Five-Year Outcomes After Treatment for
24 482 Acute Instability of the Tibiofibular Syndesmosis Using a Suture-Button Fixation
25 483 System. *Orthopaedic journal of sports medicine* 2017;5(4):2325967117702854.
26 484 doi: 10.1177/2325967117702854 [published Online First: 2017/05/17]
27 485 35. Ryan PM, Rodriguez RM. Outcomes and Return to Activity After Operative Repair
28 486 of Chronic Latent Syndesmotic Instability. *Foot & ankle international*
29 487 2016;37(2):192-7. doi: 10.1177/1071100715606488 [published Online First:
30 488 2015/09/20]
31 489 36. McGuine TA, Hetzel S, Wilson J, et al. The effect of lace-up ankle braces on injury
32 490 rates in high school football players. *Am J Sports Med* 2012;40(1):49-57. doi:
33 491 10.1177/0363546511422332 [published Online First: 2011/09/20]
34 492 37. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in
35 493 professional football: the UEFA injury study. *Br J Sports Med* 2011;45(7):553-8.
36 494 doi: 10.1136/bjism.2009.060582 [published Online First: 2009/06/26]

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5 497 **Figure 1:** Seasonal variation in injury incidence of syndesmotic injuries in professional
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12 500 **Figure 2:** Seasonal variation of the proportion of syndesmotic injuries of all ankle
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15 501 ligament injuries in professional football.

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17 502 *MA*, moving average;

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22 504 **Figure 3:** Distribution of syndesmotic injuries during 15 min periods of match play in
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29 507 **Figure 4:** Seasonal variation in injury burden of syndesmotic injuries in professional
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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; syndesmotie, ii; Injury incidence/1,000 exposure hours

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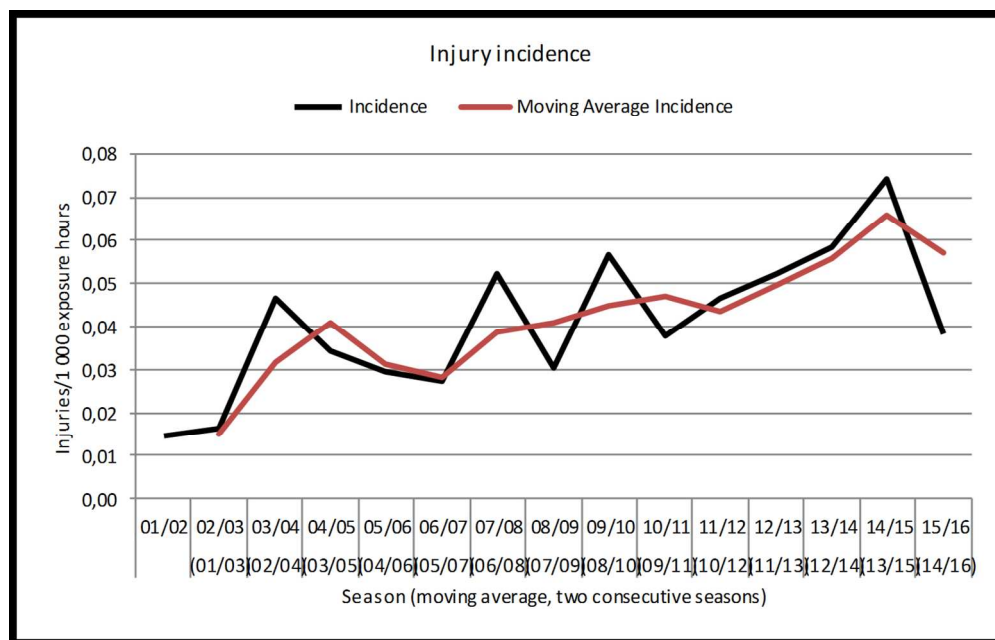
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Table 2 Definitions of variables used in the study

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 ($(\sum \text{injuries} / \sum \text{exposure-hours}) \times 1000$)
Injury burden	Number of days absence per 1000 player-hours ($(\sum \text{days absence} / \sum \text{exposure-hours}) \times 1000$)



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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 ($R^2=0.525$, $b=0.075$, 95% CI 0.032 to 0.117, $p=0.002$) over the 15 seasons. MA, moving average;

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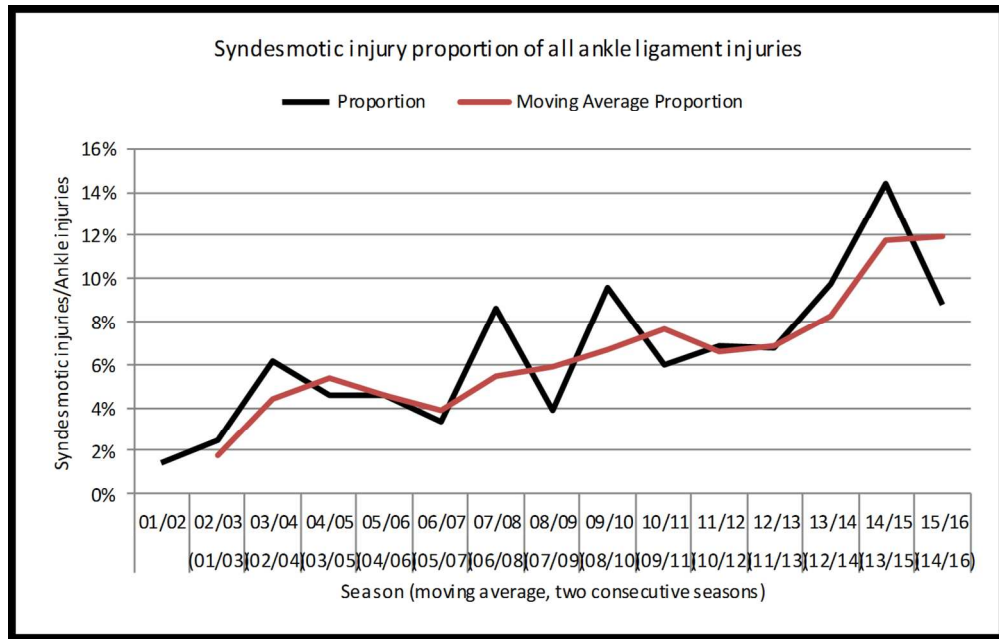


Figure 2: Seasonal variation of the proportion of syndesmotic injuries of all ankle ligament injuries in professional football. An annual 10.7% ($R^2=0.633$, $b=0.107$, 95% CI 0.058 to 0.155, $p<0.001$) increase of the proportion of syndesmotic injuries was observed.
MA, moving average;

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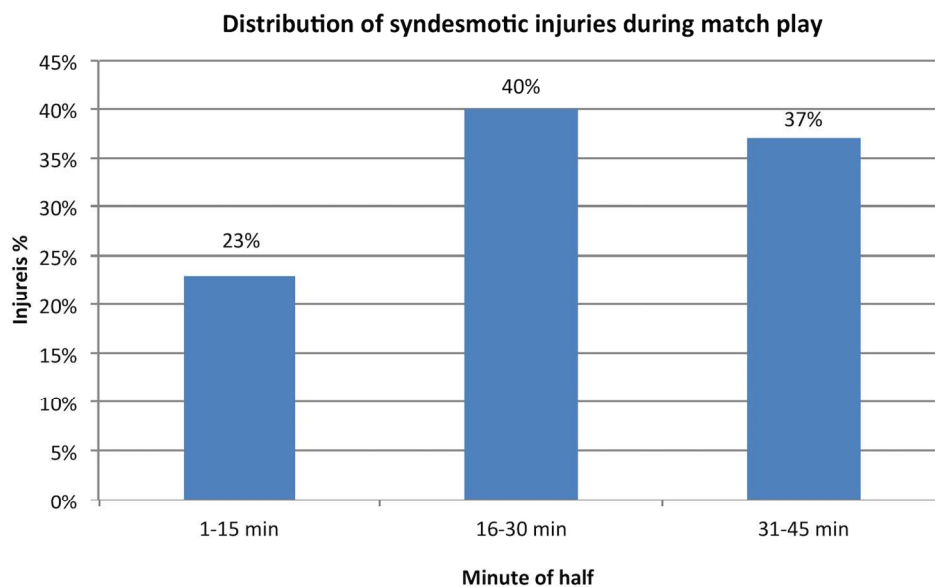


Figure 3: Distribution of syndesmotic injuries during 15 min periods of match play in professional football;

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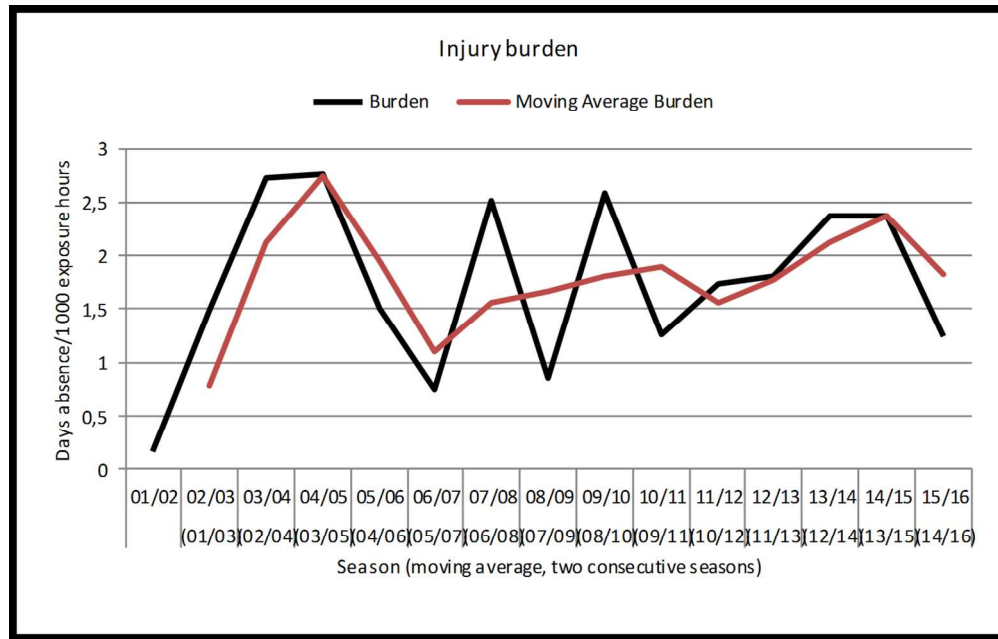


Figure 4: Seasonal variation in injury burden of syndesmotic injuries in professional football. There were no significant annual changes in injury burden ($R^2=0.123$, $b=0.058$, 95% CI -0.035 to 0.151, $p=0.200$). Similarly, no annual change was shown when the two season moving average of injury burden was analyzed. MA, moving average;

139x88mm (300 x 300 DPI)

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