Epidemiology of Muscle Injuries in Professional Football (Soccer)

Jan Ekstrand, Martin Hägglund and Markus Waldén

Original Publication:

Jan Ekstrand, Martin Hägglund and Markus Waldén, Epidemiology of Muscle Injuries in Professional Football (Soccer), 2011, American Journal of Sports Medicine.
http://dx.doi.org/10.1177/0363546510395879

EPIDEMIOLOGY OF MUSCLE INJURIES IN PROFESSIONAL FOOTBALL (SOCCER)

Jan Ekstrand, MD, PhD, Martin Hägglund, PT, PhD, Markus Waldén,

MD, PhD

From the Department of Medical and Health Sciences, Linköping University,

Sweden

Corresponding author

Jan Ekstrand, MD, PhD

Solstigen 3

SE-589 43, Linköping

Sweden

ABSTRACT

Background: Muscle injuries constitute a large percentage of all injuries in football.

Purpose: To investigate the incidence and nature of muscle injuries in male professional footballers.

Study design: ~~Prospective C~~~~c~~ohort study; level of evidence,2.g

Methods: Fifty-one football teams, comprising 2,299 players, were followed prospectively during the years 2001 to 2009. Team medical staffs recorded individual player exposure and time-loss injuries. The first-team squads of 24 clubs selected by UEFA as belonging to the best European teams, 15 teams of the Swedish First League and another 15 European teams playing their home matches on artificial turf pitches were included. A muscle injury was defined as "a traumatic distraction or overuse injury to the muscle leading to a player being unable to fully participate in training or match play".

Results: In total, 2,908 muscle injuries were registered. On average, a player sustained 0.6 muscle injuries per season. A squad of 25 players can thus expect about 15 muscle injuries per season. Muscle injuries constituted 31% of all injuries and caused 27% of the total injury absence. Ninety-two per cent of all muscle injuries affected the four major muscle groups of the lower limbs: hamstrings (37%), adductors (23%), quadriceps (19%) and calf muscles (13%). Sixteen per cent of the muscle injuries were re-injuries. These re-injuries caused significantly longer absences than index injuries. The incidence of muscle injury increased with age. When separated into different muscle groups, however, an increased incidence with age was found only for calf muscle injuries and not for hamstring, quadriceps or hip/groin strains.

Conclusion: Muscle injuries are a substantial problem for players and their clubs. They constitute almost one-third of all time-loss injuries in men's professional football and 92% of all injuries affect the four big muscle groups in the lower limbs.

Key terms: Strain, hamstrings, quadriceps, adductors, groin, artificial turf

What is known about the subject: Muscle injuries are common in football. Hamstring strain is the single most common injury subtype. The incidence of muscle injury seems to increase with age. Recurrent muscle injuries are frequently seen.

What this study adds to existing knowledge: Muscle injuries are a substantial problem for the players and clubs; a player can expect a muscle injury every second season and a team can expect about 15 muscle injuries each season. The absolute majority (92%) of muscle injuries affect four muscle groups (hamstrings, quadriceps, adductors and calf). Re-injuries have significantly longer rehabilitation times than index injuries. The incidence of muscle injury in general increases with age. However, when separated into muscle groups, an increased incidence with age has been found for calf muscle injuries only, and not for hamstring, quadriceps or hip/groin injuries. The results of this study underline the necessity to further classify heterogeneous muscle injuries into more homogenous subgroups.

INTRODUCTION

Muscular injury is one of the major problems facing football players and is reported to represent 20–37% of all time-loss injuries at men's professional level[1, 2, 4, 9, 10, 13, 16, 21, 22] and 18–23% at men's amateur level.[3, 15] Muscle injuries are a heterogeneous group of different injury types and somewhat diffuse terminology. Traditionally, they have simply been categorised as delayed onset muscle soreness (DOMS), strains (distraction injuries) and contusions (compression injuries).[20] Recently, however, muscle injuries were classified into functional and structural-mechanical injuries, where functional injuries are minor fatigue-induced or neurogenic injuries causing hardening of the muscle, while structural-mechanical injuries are muscle tears or strains of muscle fibres or bundles.[18] The first step in injury prevention is to evaluate the epidemiology of injuries and establish injury risk and injury circumstances.[17] Although muscle injuries occur frequently, our understanding of the factors that predispose players to muscle injury is limited. Prospective epidemiological studies of this type can be expected to provide the benchmark data for establishing injury prevention and rehabilitation programmes. Unfortunately, few prospective studies have been carried out that both involve senior professional footballers and provide the level of detailed information on muscle injuries that is required for this purpose.

The purpose of this study was to investigate the incidence and nature of muscle injury in a homogenous group of male professional footballers. Our hypotheses were that muscle injuries constitute a large percentage of all injuries in football, with major practical consequences for teams and players

METHODS

Participants and study cohorts

The study population consisted of three male European cohorts: the UEFA (Union of European Football Associations) Champions League cohort (UCL), the Swedish First League cohort (SWE), and the artificial turf cohort (ART).

The study cohorts comprised 51 teams (2,299 players) in total, followed over a varying number of seasons (1 to 9 seasons). The UCL cohort comprised 24 European professional teams (1,210 players), selected by UEFA as belonging to the 50 best European teams and followed over 1 to 8 seasons between July 2001 and June 2009 (4.3 seasons/team or 45.3 months/team). The SWE cohort comprised 15 Swedish top division teams (508 players) followed over 1 to 3 seasons (January to November) in 2001, 2002 and 2005 (2.3 seasons/team or 23.3 months/team). The ART cohort included 15 teams (661 players) from the top 2 domestic divisions in 8 European countries (5 teams from Sweden and 10 from other countries) followed over 1 to 7 seasons between February 2003 and December 2009 (3.3 seasons/team or 30.3 months/team). The full methodology and the validation of the study design are reported elsewhere.[11] Briefly, all contracted players in the first teams were invited to participate in the study. Players who left the team during the season, e.g. due to a transfer, were included for their time in the team. Anthropometric data and other characteristics of the cohorts are shown in Table 1. Teams were followed during the full football season, including the pre-season. Teams in the UCL and SWE cohorts trained and played their home matches on natural grass. Teams in the ART cohort all played on third generation artificial turf at their home grounds and also trained mainly on artificial turf.

Table 1 near here

Study procedure

The study design followed the consensus on definitions and data collection procedures in studies of football injuries outlined in the consensus document[6] and by UEFA.[11] To ensure high reliability of data registration, all teams were provided with a study manual containing definitions and describing the procedures used to record data, including fictive examples. To avoid language problems, the manual and the study forms were translated from English into five other languages; French, Italian, Spanish, German and Russian. In addition, all reports were checked each month by the study group and feedback was sent to the teams in order to correct any missing or unclear data.

Player baseline data were collected once yearly, at the start of each season. Individual player participation in training and matches (minutes of exposure) was registered by the club contact person on a standard exposure form sent to the study group on a monthly basis. This included exposure with the first and second team, as well as any national team exposure, for all players. The total exposure for a team during a 90 min match is 16.5 hours (11 times 90 minutes). The team medical staffs recorded injuries on a standard injury form that was sent to the study group each month. The injury form provided information about the diagnosis, nature and circumstances of injury occurrence. All injuries resulting in a player being unable to fully participate in training or match play (i.e. time-loss injuries) were recorded, and the player was considered injured until the team medical staff allowed full participation in training and availability for match selection. Injuries were categorised under four degrees of severity based on the number of days' absence. All injuries were followed until the final day of rehabilitation. The registration of a muscle injury was based on a clinical examination by the team medical staff. No specific diagnostic criteria were sent out in advance. A muscle injury

was defined as "a traumatic distraction or overuse injury to the muscle leading to a player being unable to fully participate in training or match play". Structural-mechanical injuries such as total and partial muscle ruptures, as well as functional injuries such as fatigue-induced or neurogenic muscle hardening (hypertonia) or cramps, were included in the muscle injury group while contusions, haematoma, tendon ruptures and chronic tendinopathies were excluded. The definitions applied in the study are shown in Table 2.

Table 2 near here

Data concerning injury circumstance (contact/non-contact, match period) was collected from 2005/06 in the UCL cohort and from 2009 in the ART cohort.

Analyses

ANOVA with Bonferroni post-hoc test was used for group comparisons of continuous normally distributed data (age, height, weight, squad size and mean absence/injury). Injury incidence, calculated as the number of injuries per 1,000 player hours, was analysed with rate ratios (RR) and 95% confidence intervals (95% CI), and was significance tested using z-statistics. One sample proportional test was used for analysis of proportions. All hypothesis were two-sided with a significance level set at $p<0.05$ and Bonferroni-adjusted for multiple comparisons. Ages were divided into three analysis groups based on mean ±1 standard deviations (<22 years, 22–30 years and >30 years).

Written informed consent was collected from each player in accordance with the Declaration of Helsinki. The study protocol involving the Swedish teams was approved by the Regional Ethical Review Board in Linköping, Sweden, and the study protocol for the European

professional teams was approved by the UEFA Football Development Division and the UEFA Medical Committee.

RESULTS

Prevalence and incidence of injuries

There were, on average, 25 ±4 players included per team, the squad size in the UCL and ART cohorts being significantly larger than the SWE cohort (26 ±4 and 25 ±3 v 22 ±2, $p<0.01$). Overall, 1,175,000 hours of exposure (998,000 of training and 177,000 of match play) were registered.

In total, 2,908 muscle injuries were registered with 53% occurring during matches and 47% during training. On average, a player sustained 0.6 muscle injuries per season. The prevalence and incidence of injuries are shown in Table 1. Muscle injuries constituted 31% (2,908/9,275) of the total number of injuries registered in the three cohorts, and caused 27% of the total injury absence in the clubs. Each season, 37% of players missed training or match play due to muscle injuries.

The injury incidence was six times higher during match play compared to training (8.70 v 1.37/1,000 hours, $p<0.001$). The incidence of match play injuries was lower for the artificial turf cohort (6.16/1,000hrs) compared with the two cohorts that played their home matches on natural grass (UCL 9.58/1,000 hrs, $p<0.001$; and SWE 8.75/1,000hrs, $p<0.001$). The injury incidence during training was higher in the SWE cohort (1.67/1,000hrs) than in the UCL (1.38/1,000hrs, $p=0.003$) and ART (1.11/1,000hrs, $p<0.001$) cohorts. The mean absence for muscle injuries was longer in the UCL cohort (16 days) than in the two other cohorts (SWE 12 and ART 12 days, both $p<0.001$) (Table 1).

Injury location and leg dominance

Ninety-two per cent of injuries affected the lower extremities. The hamstrings (37%), adductors (23%), quadriceps (19%) and calves (13%) were the most common injury locations (see Table 3). Injury to the hamstring muscle group was the most common single injury subtype, representing 12% of all injuries. The majority of quadriceps strains (60%) affected the dominant leg (preferred kicking leg), 33% the non-dominant leg and 7% either affected both legs or the leg dominance was unknown ($p<0.05$). The dominance of muscle injuries to the kicking leg was less obvious in other muscle groups (hamstrings 50%, adductors 54% and calf muscles 51%).

Injury circumstances

Two out of three muscle injuries were traumatic with an acute onset. Overuse injuries with a gradual onset were more common among hip/groin injuries than among injuries to the hamstrings, quadriceps and calf muscles (42 v 30, 26 and 28%, $p<0.001$). Almost all muscle injuries occurred in non-contact situations (92% adductors, 96% quadriceps and hamstrings and 95% calf muscles), and only 5% occurred during foul play.

Variation during matches

The distribution of injuries during the 90 minutes of a match is shown in Figure 1. Thigh strains tended to occur less frequently in the first quarter of each half, showing a significant trend in the first half for quadriceps strains (p=0.035). Similarly, hip/groin strains were less frequent in the first part of each half (first half p<0.001; second half p=0.012). Calf strains were most frequent in the last 15 minutes of the match (p<0.05, compared with 0–15, 15–30, 30–45 and 60–75 minutes)

Fig 1 near here

Muscle injuries and age

The incidence of muscle injury in general increased with age (Figure 2). In training, players in the oldest age group (>30 years) had a significantly higher incidence than young (<22 years) players (1.19 v 1.63/1,000 hours, p=0.0003), while it was no different from that of the intermediate (22–30 years) age group (1.39/1,000 hours). In match play, young players had a lower incidence (6.26/1,000 hours) than the intermediate (9.24/1,000 hours, p<0.0001) and older (9.54/1,000 hours, p<0.0001) age groups.

Fig.2 near here

The match play incidence of the four most common muscle strain injuries was also analysed between the age groups (Figure 3). There were no inter-group differences in the incidence of hamstring or quadriceps strains (all p>0.0167). The incidence of groin strains was highest in

the intermediate age group (2.71/1,000 hours) and lowest among the younger players (1.61/1,000 hours, p<0.0003 v intermediate group). The incidence of calf strains increased with age, with 0.32/1,000 hours for young players, 1.07 in the intermediate age group (p=0.0001 v young players) and 1.89 for older players (p<0.0001 v intermediate group; p=0.0007 v young players).

Fig 3. near here

Re-injuries

As seen in Table 1, 16% of the muscle injuries were re-injuries, the recurrent rate being significantly lower in the UCL cohort (13%) compared to the ART (20%, p<0.001) and SWE cohorts (22%, p<0.001). The recurrent injuries had a significantly longer absence time compared with index injuries (17.8 ±25.2 v 13.8 ±17.0 days, p<0.001). The median days lost for index and recurrent injuries was 9 and 10 days respectively (10 vs 13 days in the UCL cohort, 8 vs 10 days in the ART cohort and 6 vs7 days in the SWE cohort). As seen in Table 3, there was no difference in the recurrence rate between the four most common injury locations (adductors 17%, hamstrings 16%, quadriceps 17% and calves 13%).

Consequences of muscle injuries

Diagnoses, days' absence and recurrence rates are shown in Table 4. In general, a football team with 25 players can expect about 15 muscle injuries per season (see Table 5 for a pragmatic list of the average burden on a team). The majority of injuries resulted in absences

of more than one week (58%), and 11% were severe, causing absences more than four weeks from training and match play (Table 3).

Quadriceps strains caused significantly longer absences (17 days) than hamstring (14 days, $p=0.009$) and hip/groin strains (13 days, $p<0.001$), but not significantly longer than calf strains (15 days, $p=0.08$).

DISCUSSION

The main findings of this study were that almost one-third of all injuries in professional football are muscle injuries and that the vast majority (92%) affect the four major muscle groups of the lower limbs: hamstrings 37%, adductors 23%, quadriceps 19% and calf muscles 13%. It is well established that the majority of football injuries affect the lower extremities[4, 21, 22] and this seems to be even more pronounced when it comes to muscle injuries. Another important finding of this study, with high clinical relevance for practitioners on the field, is that re-injuries cause significantly longer lay-offs than non-recurrent injuries.

Substantial consequences for clubs and players

Although most players were able to return to full training and match play within four weeks, muscle injuries are a substantial problem for the players and their clubs. They constitute almost one-third of all injuries and caused more than a quarter of the total injury absence in the clubs studied. A team of 25 players at elite level can expect about 15 muscle injuries each season with approximately two weeks missed for each injury. This quantity of time loss could be devastating, since players sidelined due to injury limit the possibility of optimal performance by the team.

Re-injuries cause 30% longer absences

The early recurrence rate was significantly lower in the UCL cohort than in the SWE and ART cohorts. This tallies with findings for overall re-injury rates reported previously from the same cohorts.[4, 12-14, 21, 22] One possible explanation for the difference might be that top level clubs in Europe have greater medical support, providing the possibility of more individualised rehabilitation for injured players. One could also speculate as to whether radiological examinations are more frequently used in top clubs for diagnostics and return-to-play

decisions, and whether this could help to reduce re-injury rates. However, this hypothesis should be verified in future studies. Re-injuries caused longer absence than non-re-injuries, which is in accordance with previous findings.[4, 21, 22] Improvements in controlled rehabilitation with functional tests before returning to team training and match play might reduce the risk of re-injury even more.[7]

More injuries towards the end of each half

We found the incidence of muscle injuries in matches to be six times higher than in training, a finding that tallies with other studies.[4, 19] Furthermore, muscle injuries tended to occur more frequently towards the end of each half, a finding that is also in line with other studies.[4, 9] One might speculate as to whether fatigue might be an explanation for these findings. It has recently been shown in a laboratory study of ten male professional footballers that the eccentric hamstrings' strength decreased over time and, in particular, after the half-time interval.[8] A limitation in our analysis, however, was that no adjustment was made for player substitutions, i.e. it is not known whether a player who sustained an injury at the end of a match had started the match or not.

Lower incidence of muscle injury when playing on artificial turf?

The incidence of match play muscle injuries was significantly lower for the artificial turf cohort than the two cohorts that played their home matches on natural grass. The match play injuries for the ART cohort includes the injuries sustained at home matches on artificial turf but also injuries sustained at away matches mainly played on natural grass. A decreased incidence of lower extremity muscle injuries when playing on new-generation artificial turf has been observed in other studies where the same teams have been followed when playing their home matches on artificial turf and the majority of their away matches on natural grass,

thus eliminating many of the confounding factors related to inter-team differences, e.g. reporting variations and differences in climate.[5]

Fewer muscle injuries in younger players

The incidence of muscle injury in general increased with age. A similar finding is often referred to in the literature.[2, 14] However, when performing a sub-analysis of the incidence of different types of muscle injury in different age groups, which is possible if the material is large enough, it is found that the increase with age is only valid for calf strains and not for hamstring, quadriceps and hip/groin strains.

Methodological considerations

The strength of this study is its design, with a large homogenous population group of male professional footballers followed prospectively with a standardised methodology that complies with the international consensus agreements on procedures for epidemiological studies of football injuries.[6, 11] The study provides information about the nature, incidence and severity of muscle injuries. However, the heterogeneity of the material of muscle injuries makes prognoses regarding healing time and rehabilitation difficult. The material includes all types of muscle injuries including total and partial muscle ruptures as well as muscle hypertonia and cramps. Furthermore, the material includes muscle injuries of different severities, of different extra and intra-muscular locations and of different sizes. The correlation between age and muscle injuries in this study underlines the necessity to further classify the heterogeneous group of all muscle injuries into more homogenous subgroups: as seen in Figure 2, the incidence of muscle injury in general increased with age, but when

muscle injuries were divided into subgroups, such an increase with age was only valid for the calf muscles group and not for hamstring or quadriceps injuries (Figure 3).

Future studies should address the possibility of making more a accurate healing time prognosis for muscle injuries when classified into subgroups by means of clinical and/or radiological examinations.[18] Furthermore, the risk factors and mechanisms of the most common muscle injuries should be studied in more detail in order to generate ideas for preventive measures.

ACKNOWLEDGMENTS

The authors wish to thank the participating clubs, medical staffs and players. The statistical advice of Henrik Magnusson (Msc) is also gratefully acknowledged. This study was supported by grants from UEFA, the Swedish Center for Research in Sports and Praktikertjänst AB.

REFERENCES

1. Árnason Á, Gudmundsson Á, Dahl HA, Jóhannsson E. Soccer injuries in Iceland. *Scand J Med Sci Sports.* 1996;6:40-45.

2. Árnason Á, Sigurdsson SB, Gudmundsson Á, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med.* Jan-Feb 2004;32 (Suppl 1):S5-S16

3. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc.* 1983;15:267-270.

4. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in professional football - the UEFA injury study. *Br J Sports Med.2009* Jun 23 [Epub ahead of print] PMID: 19553225.

5. Ekstrand J, Timpka T, Hagglund M. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study. *Br J Sports Med.* 2006;40:975-980.

6. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40:193-201.

7. Fuller CW, Walker J. Quantifying the functional rehabilitation of injured football players. *Br J Sports Med.* 2006;40:151-157..

8. Greig M, Siegler JC. Soccer-specific fatigue and eccentric hamstrings muscle strength. *J Athl Train.* 2009;44:180-184.

9. Hawkins RD, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med.* 1999;33:196-203.

10. Hawkins RD, Hulse MA, Wilkinson C, Hodson A, Gibson M. The association football medical research programme: an audit of injuries in professional football. *Br J Sports Med.* 2001;35:43-47.

11. Hägglund M, Waldén M, Bahr R, Ekstrand J. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med.* 2005;39:340-346.

12. Hägglund M, Walden M, Ekstrand J. Exposure and injury risk in Swedish elite football: a comparison between seasons 1982 and 2001. *Scand J Med Sci Sports.* 2003;13:364-370.

13. Hägglund M, Waldén M, Ekstrand J. Injury incidence and distribution in elite football - a prospective study of the Danish and the Swedish top divisions. *Scand J Med Sci Sports.* 2005;15:21-28.

14. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med.* 2006;40:767-772.

15. Inklaar H. Soccer injuries. I: Incidence and severity. *Sports Med.* 1994;18:55-73.

16. Junge A, Dvorak J, Graf-Baumann T, Peterson L. Football injuries during FIFA tournaments and the Olympic Games, 1998-2001: development and implementation of an injury-reporting system. *Am J Sports Med.* 2004;32(Suppl 1):S80- S89.

17. Mechelen Wv, Hlobil H, Kemper H. Incidence,severity, aetiology and prevention of sports injuries. *Sports Med.* 1992;14:82-99.

18. Müller-Wohlfahrt H, Ueblacker P, Hänsel L. *Muskelverletzungen im Sport*. Stuttgart: Georg Thieme Verlag KG; 2010.

19. Petersen J, Thorborg K, Nielsen MB, Holmich P. Acute hamstring injuries in Danish elite football: A 12-month prospective registration study among 374 players. *Scand J Med Sci Sports. 2009* Oct 4 [Epub ahead of print] PMID: 19804375.

20. Saartok T. Muscle injuries associated with soccer. *Clin Sports Med.* 1998;17:811-817.

21. Walden M, Hagglund M, Ekstrand J. Injuries in Swedish elite football--a prospective study on injury definitions, risk for injury and injury pattern during 2001. *Scand J Med Sci Sports.* 2005;15:118-125.

22. Walden M, Hagglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001-2002 season. *Br J Sports Med.* 2005;39:542-546.

Table 1. Player and cohort characteristics

	Total	UCL[1]	SWE[1]	ART[1]
No. of teams (team seasons[2])	51 (188)	24 (104)	15 (35)	15 (49)
No. of players (player seasons[2])	2299 (4658)	1210 (2686)	508 (774)	661 (1198)
Player anthropometrics[3]				
Age (years)	25.3 ± 4.6	25.7 ± 4.5	24.8 ± 4.7	25.0 ± 4.8
Height (cm)	181.8 ± 6.2	181.7 ± 6.4	182.5 ± 5.7	181.8 ± 6.2
Weight (kg)	78.2 ± 6.8	78.0 ± 7.0	79.0 ± 6.1	78.1 ± 6.9
Exposure training (hours/player/season)[3]	214±80	210±73†	262±71‡§	193±89†‡
Exposure match (hours/player/season)[3]	38±22	41±24†	38±17‡§	32±20†‡
No. of muscle injuries	2908 (31%)	1821 (34%)†	595 (34%)‡	492 (22%)†‡
(% of total No. of injuries)				
Season prevalence	37%	41%†	41%‡	27%†‡
Total injury incidence[4] (95% CI)	2.48 (2.39-2.57)	2.70 (2.58-2.83)†	2.58 (2.38-2.79)‡	1.82 (1.67-1.99)†‡
Injury incidence, training[4]	1.37 (1.30-1.45)	1.38 (1.29-1.48)†§	1.67 (1.50-1.86)‡§	1.11 (0.98-1.25)†‡
Injury incidence, match[4]	8.70 (8.28-9.14)	9.58 (9.02-10.18)†	8.75 (7.74-9.88)‡	6.16 (5.42-7.00)†‡
Injury severity				
Minimal (1–3 days)	432 (15%)	215 (12%)	142 (24%)	74 (15%)
Mild (4–7 days)	786 (27%)	432 (24%)	197(33%)	157 (32%)
Moderate (8–28 days)	1366 (47%)	927 (51%)	208 (35%)	231 (47%)
Severe (>28 days)	324 (11%)	246 (13%)	48 (8%)	30 (6%)
Mean ± SD days' absence/injury	14.4 ± 18.5	15.9 ± 18.0†§	11.9 ± 20.9§	12.0 ± 16.8†
Injury burden[5]	35.7 (35.4-36.1)	43.1 (42.5-43.6)†§	30.6 (29.9-31.3)‡§	21.8 (21.3-22.4)†‡
Re-injuries	452 (16%)	228 (13%)†§	128 (22%)§	96 (20%)†

[1] UEFA Champions League (UCL), Swedish Super League (SWE), UEFA artificial turf (ART)

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

[3] Values are mean ± standard deviation

[4] Incidence of muscle injuries expressed as No. of injuries/1,000 hours of total exposure (95% CI)

[5] Injury burden expressed as No. of days' absence/1,000hrs of total exposure (incidence × mean absence) (95% CI)

† Significant difference between ART and UCL cohorts

‡ Significant difference between ART and SWE cohorts

§ Significant difference between UCL and SWE cohorts

Table 2. Operational definitions

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

Table 3. Incidence, prevalence and nature of four most common muscle injuries.

	Hamstrings	Quadriceps	Adductors	Calf muscles
n (% of total no of injuries)	1084 (12%)	485 (5%)	672 (7%)	368 (4%)
Season prevalence	17%	8%	14%	6%
Total injury incidence[1] (95% CI)	0.92 (0.87-0.98)	0.41 (0.38-0.45)	0.57 (0.53-0.62)	0.31 (0.28-0.35)
Injury incidence, training[1]	0.43 (0.39-0.47)	0.28 (0.25-0.32)	0.32 (0.29-0.36)	0.18 (0.16-0.21)
Injury incidence, match[1]	3.70 (3.43-3.99)	1.15 (1.00-1.32)	2.00 (1.80-2.22)	1.04 (0.90-1.20)
Injury severity				
Minimal (1–3 days)	140 (13%)	60 (12%)	119 (18%)	50 (14%)
Mild (4–7 days)	272 (25%)	120 (25%)	210 (31%)	93 (25%)
Moderate (8–28 days)	556 (51%)	233 (48%)	275 (41%)	177 (48%)
Severe (>28 days)	116 (11%)	72 (15%)	68 (10%)	48 (13%)
Mean ± SD days' absence/injury	14.3 ± 14.9	16.9 ± 19.2	14.0 ± 24.3	14.7 ± 14.4
Injury burden[2]	13.2 (13.0-13.4)	7.0 (6.8-7.1)	8.0 (x-y)	4.6 (4.5-4.7)
Re-injuries	174 (16%)	81 (17%)	124 (18%)	48 (13%)

[1] Injury incidence for muscle injuries expressed as No. of injuries/1,000 hours of total exposure (95% CI)

[2] Injury burden expressed as No. of days' absence/1,000 hours of total exposure (incidence × mean absence) (95% CI)

Table 4. Days' absence and recurrence rates for muscle injuries depending on location

Location	n	Days' absence[1]	Range	Recurrence rate (%)
Cervical	10	4.5 ± 3.3	1-10	10
Upper arm	3	3.7 ± 1.5	2-5	0
Chest	4	3.8 ± 2.1	2-6	25
Abdominal	24	12.6 ± 9.2	3-46	4
Lumbar	32	8.0 ± 6.2	1-28	3
Groin, adductors	672	14.0 ± 6.2	0-361	18
Hip, iliopsoas	93	12.3 ± 12.9	1-60	12
Hip, gluteal	55	7.2 ± 4.8	1-29	0
Hamstrings	1084	14.3 ± 14.9	1-128	16
Quadriceps	485	16.9 ± 19.2	1-147	17
Sartorius	26	22.5 ± 50.5	2-247	12
Tensor fascia latae	7	11.4 ± 12.9	2-30	14
Calf	368	14.7 ± 14.4	1-95	13
Lower leg	13	10.4 ± 6.6	3-29	8

[1] Values are mean ± SD

Table 5. Consequences of muscle injuries during a season for a typical 25-player squad

	N	Total absence (days)	No of missed matches	No of missed trainings
All muscle injuries	15	223	37	148
Hamstrings	4-6	82	14	55
Quadriceps	2-3	44	8	29
Hip/groin	4	58	9	38
Calf muscles	2	29	5	19

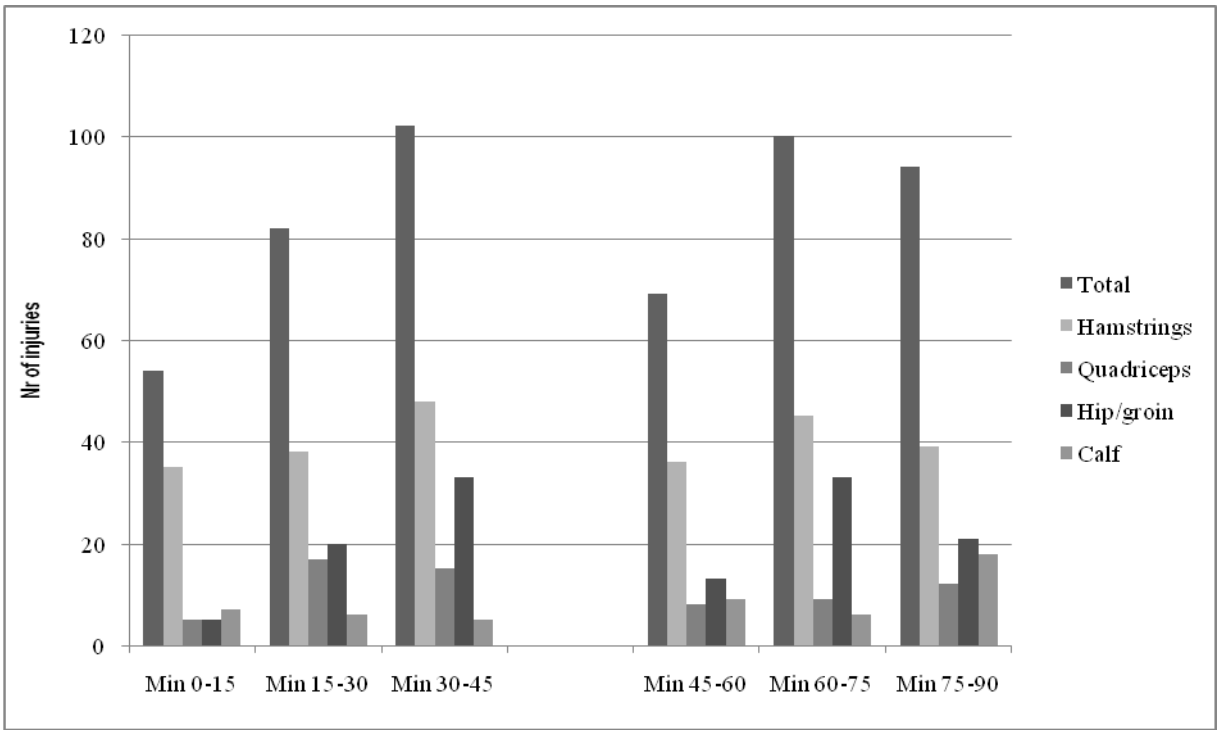

Figure 1. Distribution of traumatic injuries during a match (data from the UCL cohort, 2005–09).

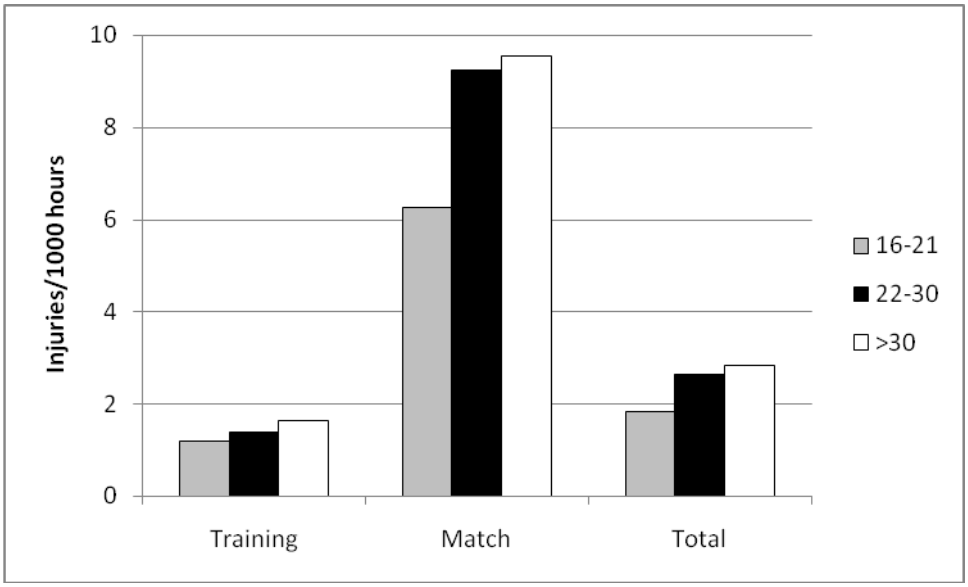

Figure 2. Muscle strain incidence in age groups 16–21 years (>1 SD below mean age), 22–30 years (mean age ± 1 SD) and >30 years (>1 SD above mean age).

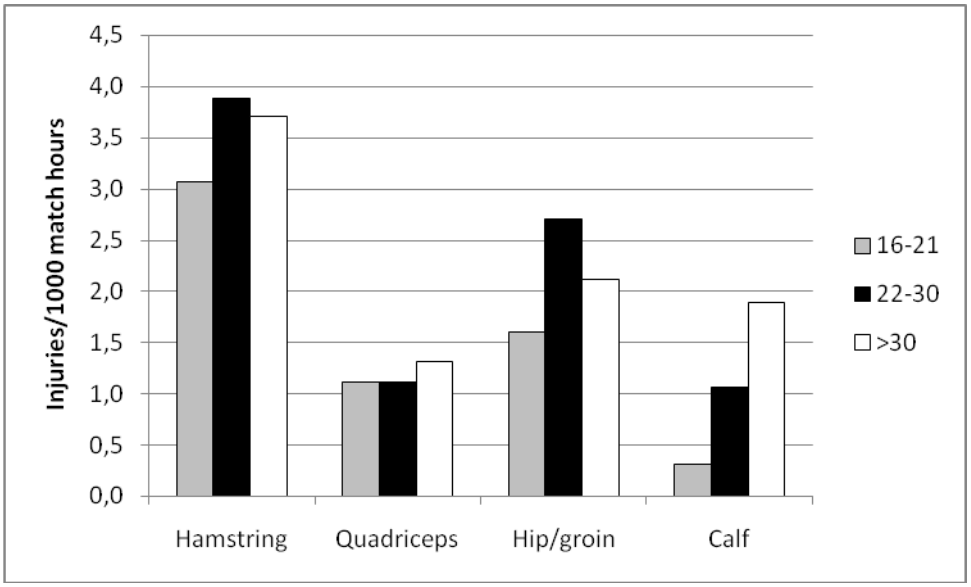

Figure 3. Match incidence of four most common muscle strain injuries in age groups 16–21 years (>1 SD below mean age), 22–30 years (mean age ± 1SD) and >30 years (>1 SD above mean age).