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9 **A Four-season Prospective Study of Muscle Strain**

10 **Reoccurrences in A Professional Football Club**

11
12 Authors: ^{1,2}Christopher Carling, ¹Franck Le Gall, ³Emmanuel Orhant

13
14
15
16 Institutions:

17 ¹ *LOSC Lille Métropole Football Club, Domain de Luchin, Camphin-en-Pévèle, 59780,*
18 *France;*

19 ² *Institute of Coaching and Performance, University of Central Lancashire, Preston,*
20 *PR1 2HE, UK;*

21 ³ *Olympique Lyonnais Football Club, 350 avenue Jean Jaurès, 39361, Lyon, Cedex 07,*
22 *France.*

23
24 Correspondance: Christopher Carling, EMSP, LOSC Lille Métropole Football Club,
25 Domain de Luchin, Camphin-en-Pévèle, 59780, France.

26 Phone: 00.33.6.0392 1861

27 Fax: 00.33.1.4891 0793

28 Email: chris.carling@free.fr

29
30 Running head: Muscle strains in elite football

1 **Abstract**

2 The aim of this investigation was to characterise muscle strain re-injuries and examine
3 their impact on playing resources in a professional football club. Muscle strains and
4 reoccurrences were prospectively diagnosed over four seasons in first-team players
5 (n=46). Re-injury was defined as an injury of the same type and at the same site as an
6 index injury and which occurred after a player's return to full participation from the
7 index injury. Altogether, 188 muscle strains were diagnosed with 44 (23.4%) of these
8 classed as re-injuries leading to an incidence of 1.32 strain reoccurrences per 1000 hours
9 exposure (95% Confidence Interval, 0.93-1.71). The incidence of recurrent strains was
10 higher in match-play compared to training (4.51, 95% Confidence Interval, 2.30-6.72 vs
11 0.94, 95% Confidence Interval 0.59-1.29). Altogether, 50.0% of players sustained at
12 least 1 reoccurrence of a muscle strain leading to approximately 3 days lost and 0.4
13 matches missed per player per season. The incidence of recurrent strains was highest in
14 centre-forwards (2.15, 95% Confidence Interval, 1.06-3.24), peaked in May (3.78, 95%
15 Confidence Interval, 0.47-7.09) and mostly affected the hamstrings (38.6% of all
16 reoccurrences). Mean layoff for non-reoccurrences and recurrences was similar: ~7.5
17 days. These results provide greater insight into the extent of the problem of recurrent
18 muscle strains in professional football.

19

20 **Keywords:** Football; Re-injury; Injury, Epidemiology, Absence

21

1 **Introduction**

2
3 Contemporary professional football is known to be associated with relatively
4 high injury rates when compared to other team sports. Research across professional
5 European football has shown that approximately 12% of the playing season is lost due
6 to injury (Ekstrand, Hägglund and Waldén 2009) and that injury is the main factor
7 affecting player availability (Orhant, Carling and Cox 2010, Parry and Drust 2006).
8 Another major concern identified across epidemiological studies in elite football is the
9 high risk of injury reoccurrence just after return to play. Re-injury rates from 12%
10 (Ekstrand, Hägglund and Waldén 2009) to 30% (Hägglund, Waldén and Ekstrand 2005)
11 have been reported in professional football players when defining re-injury as an
12 identical injury to the same location within 2 months after return to play. In addition,
13 injury reoccurrences in professional football are generally shown to cause a
14 substantially longer absence from play than non-reinjuries (Hawkins and Fuller, 1999;
15 Hawkins, Hulse, Wilkinson et al. 2001; Waldén, Hägglund and Ekstrand, 2005a;
16 Ekstrand, Hägglund and Waldén 2009) although one study has reported a similar layoff
17 time (Waldén, Hägglund and Ekstrand, 2005b). In elite football, previous injury, return
18 to activity prematurely, inadequate rehabilitation and incomplete recovery are potential
19 risk factors involved in recurrent injuries (Arnason, Sigurdsson, Gudmundsson et al.
20 2005).

21 The injury types sustained in professional football players are predominantly
22 muscle strains (Woods, Hawkins, Hulse et al. 2002; Ekstrand, Hägglund and Waldén
23 2009). In relation to this, re-injury rates as high as 30% have previously been reported
24 for muscular strains (Hawkins and Fuller 1999). Indeed, muscles that are not fully
25 restored structurally and/or functionally are likely risk factors in recurrent muscular
26 strains (Arnason, Sigurdsson, Gudmundsson et al. 2005). Yet, there is no detailed
27 information in the current medical literature on the impact of muscle strain reinjuries on

1 playing resources: proportions of the playing squad affected and unavailable to play and
2 working days lost or matches missed each season. Similarly, no studies have explored
3 the distribution of muscle strain reoccurrences across the playing season and whether
4 frequency and patterns vary between playing positions. Finally, studies generally report
5 information on ‘early’ recurrent strains that is those sustained within 2 months of a
6 player’s return to full participation (Hägglund, Waldén and Ekstrand 2005; Ekstrand,
7 Hägglund and Waldén 2009) and no data are available on later reoccurrences of muscle
8 strains although these injuries should be taken into account (Fuller, Ekstrand, Junge et
9 al. 2006). As a whole, this information would provide greater insight into the extent of
10 the re-injury problem in professional football whilst informing appraisal of current
11 injury prevention and rehabilitation regimens.

12 The aims of this prospective investigation of muscle strain reoccurrences in a
13 professional football club were two-fold: 1) to quantify the impact of muscle strain
14 reinjuries on playing resources; 2) to investigate the characteristics of muscle strain
15 reoccurrences over a 4-season period.

16

17 **Methods**

18 In this study, muscle strain injuries and re-injuries in male football players (ages
19 17-34 years) belonging to the first-team squad of a French League-1 Club were
20 investigated. While approval for the study was obtained from the present club, these
21 data arose as a condition of employment in which player performance was routinely
22 measured over the course of the competitive season and usual appropriate ethics
23 committee clearance was not required (Winter and Maughan, 2009). Nevertheless, to
24 ensure team and player confidentiality, all injury data were anonymised before analysis.

25 Data were collected in 46 players who participated in one or more full seasons
26 over a four-season period (2005-2006, 2006-2007, 2007-2008 and 2008-2009). Data in

1 players who started but did not complete an entire season were not included. Altogether,
2 12 (26.1%), 18 (39.1%) and 16 (34.8%) players participated in one, two or three/four
3 entire seasons respectively. Over the course of the study, the number of players in each
4 playing position included: 5 goalkeepers, 13 defenders, 15 midfielders and 13 forwards.
5 Players participated in up to 7 training sessions per week and 50 competitive matches
6 per season. Individual exposure time to official competition (domestic League and Cup,
7 and European Competition) and pre-season friendly matches was recorded for players
8 belonging to the first-team squad. Exposure time to first-team training sessions was
9 recorded for the squad as a whole by the team physician.

10 Muscle strains and reoccurrences of strains were prospectively diagnosed and
11 documented by the team physician. Essentially, this involved routine clinical
12 assessment of players by the physician at the time of presentation. Where necessary,
13 further examinations were ordered (e.g., sonography or magnetic resonance imaging) at
14 the discretion of the physician to assist with diagnosis. The team physician (certified in
15 Sports Medicine) had over 5 years experience in this setting.

16 The definitions of injuries and recurrent injuries were based on those
17 recommended by International Football Injury Consensus Groups (Hägglund, Waldén,
18 Bahr et al. 2005; Fuller, Ekstrand, Junge et al. 2006). Injury: Time-loss injury resulting
19 from playing football and leading to a player being unable to fully participate in future
20 training or match play independent of whether a training session actually takes place on
21 the day following injury or whether a player is selected to play in the next match.
22 Specifically, strains were described as an acute distraction injury of a muscle. Recurrent
23 injury (re-injury): An injury of the same type and at the same site as an index injury and
24 which occurs after a player's return to full participation from the index injury. A
25 recurrent injury occurring within 2 months of a player's return to full participation is
26 referred to as an "early reoccurrence"; one occurring 2-12 months after a player's return

1 to full participation as a “late recurrence”; and one occurring more than 12 months after
2 a player’s return to full participation as a “delayed recurrence”.

3 The severity of the injury (layoff time) was determined according to the number
4 of days the player was absent from and unable to take full part in training or
5 competition. All injuries were followed until the final day of rehabilitation. The player
6 was considered injured until the team physician allowed full participation in collective
7 training and availability for match selection.

8 All statistical analyses were conducted using SPSS for Windows Version 14.0
9 (SPSS Inc., Chicago, IL, USA). Standard statistical procedures were used to calculate
10 means and standard deviations. Injury incidence rates are presented with 95%
11 confidence intervals.

12

13 **Results**

14 Over the 4-year study period, players belonging to the first-team squad were
15 exposed to a total of 33432 hours participation time (29884 training hours and 3548
16 match-play hours).

17 A total of 188 muscle strains were diagnosed (Table1) with 44 (23.4%) of these
18 classed as re-injuries. The incidences of muscle strains (minus reoccurrences) and
19 reoccurrences respectively were 4.31 (95% CI, 3.61-5.01) and 1.32 (95% CI, 0.93-1.71)
20 per 1000 hours play. Altogether, 74 and 114 (20.86, 95% CI, 16.11-25.61 and 3.81,
21 95% CI, 3.11-4.51) per 1000 hours exposure) muscle strains were sustained in match-
22 play and training respectively. The incidence of strain re-injuries was greater in match-
23 play (n=16) compared to training (n=28) respectively (4.51, CI 2.30-6.72, vs 0.94 CI,
24 0.59-1.29 per 1000 hours exposure). Altogether, 50.0% of players sustained at least 1
25 reoccurrence of a muscle strain. Players incurred a mean per season of 1.9 ± 1.0 muscle
26 strains and 0.4 ± 0.5 reoccurrences of these injuries. In players that completed 3 or more

1 seasons (N=16), there were 1.8 ± 1.0 muscle strains and 0.4 ± 0.4 reoccurrences of these
2 injuries per player while 75% of these players sustained at least 1 reoccurrence of a
3 muscle strain.

4 For the whole squad, recurrent strains accounted for a mean of 85 working days
5 lost and 11 matches missed per season (approximately 3 days lost and 0.4 matches
6 missed per player). Of the re-injuries, 15 (34.1%) were classed as early reoccurrences
7 while 14 (31.8%) and 15 (34.1%) were considered to be late and delayed reoccurrences
8 respectively. The majority (46.4%) of recurrent strains sustained in training were
9 classed as early occurrences. Of the total number of early reoccurrences, 86.7% were
10 incurred within 28 days of the index injury (Figure 1).

11 Overall, muscle strains were mostly located in the hamstring and quadriceps
12 regions (both ~ 1.0 per 1000 hours exposure) (Table 1). Recurrent strains were most
13 frequent in the hamstring (38.6% of all reoccurrences; 0.51 (CI 0.27-0.75) per 1000
14 hours exposure) and the groin and lower leg regions (20.5% of all reoccurrences each;
15 0.27 (CI 0.09-0.45) per 1000 hours exposure). Of the hamstring reinjuries, respective
16 incidences in match-play and training of 1.41 (CI 0.17-2.65) and 0.41 (CI 0.18-0.64)
17 were observed. The majority (80.0%) of hamstring reinjuries sustained in match-play
18 were classed as early or late reoccurrences. Recurrent injuries made up 21.2% of all
19 strains to the non-dominant leg and 26.6% of all strains to the dominant leg.

20 With respect to playing position, the incidence of muscle strain reoccurrences
21 per 1000 hours exposure (plus total number of occurrences and percentage of the total)
22 were: Goalkeepers = 1.10, CI, 0.02-2.18 (4, 14.3%); Defenders = 1.44, CI, 0.66-2.22
23 (13, 22.1%); Midfielders = 0.87, CI, 0.38-1.36 (12, 29.3%); and Forwards = 2.15, CI,
24 1.06-3.24 (15, 26.7%). In midfielders (58.3%) and forwards (46.7%) notably, strain re-
25 injuries mainly concerned the hamstring region whereas the quadriceps muscles were
26 commonly affected in defenders (38.5%).

1 The mean layoff time for muscle strains not leading to a reoccurrence = 7.8 ± 6.7
2 days, those eventually leading to a reoccurrence = 7.0 ± 5.1 days and those classed as
3 reoccurrences = 7.5 ± 6.3 days. The mean absence time as a result of muscle strain
4 reoccurrences classified according to the time delay with respect to the original injury
5 was: early reoccurrences = 7.8 ± 5.9 days; late reoccurrences = 8.7 ± 6.1 days and
6 delayed reoccurrences = 5.9 ± 6.9 days. The longest layoff time for recurrent strains was
7 observed in the groin (9.1 ± 8.7 days) and lower leg (8.2 ± 7.4 days) regions.

8 The overall incidence of muscle strains (minus reoccurrences) was highest in
9 November (5.15 per 1000 hours, CI, 2.54-7.76) (Figure 2) whereas strain re-injuries
10 peaked in May (3.78 per 1000 hours, CI, 0.47-7.09). Strain re-injury incidence rate in
11 training was highest in August (2.62 per 1000 hours, CI, 0.68-4.56) and May (2.69 per
12 1000 hours, CI, 0.06-5.45) and peaked in match-play in December (11.23 per 1000
13 hours, CI, 0.22-22.24). Of the early and late strain reoccurrences, the majority (21.4%)
14 were sustained during the first two full months of the season (July and August).

15

16 **Discussion**

17 This prospective study is the first to report in-depth data on the characteristics
18 and impact of muscle strain reoccurrences in a professional football club. Noteworthy
19 results were that half of all players incurred at least one reoccurrence of a muscle strain
20 and that the risk of re-injury was still strong 1-year following on from the original
21 injury. Recurrent muscle strains were most frequent in forward players, commonly
22 affected the hamstring region (especially in midfield and forward players) and occurred
23 throughout the competitive season. On average, players lost ~3 days and missed 0.4
24 matches per season due to reoccurrences of muscle strains.

25 Over the 4-year season period, approximately one fifth of all muscle strains were
26 classed as re-injuries which is more than the 9% and 17% rate observed in English

1 (Hawkins, Hulse, Wilkinson et al. 2001) and Swedish (Walden, Hägglund and Ekstrand
2 2005a) professional football but less than the 30% rate reported in other English
3 professional football players (Hawkins and Fuller 1999). However, 50% of the present
4 players sustained at least 1 or more reoccurrences of a muscle strain over the study
5 period. This result suggests that despite following routine controlled functional
6 rehabilitation programmes post-injury, including regular evaluation of muscle strength
7 and flexibility (Peterson and Holmich 2005, Fuller and Walker 2006), the risk of
8 incurring a reoccurrence of a previous muscle strain was still reasonably high in these
9 professional players. In addition, over a third of all re-injuries were sustained 12-months
10 on from the original injury. However, muscle strains were only observed over a 1-
11 season period in a quarter of the players and therefore delayed strain reoccurrences were
12 not accounted for in these players. Nevertheless, this finding is noteworthy and partly
13 confirms previous speculation that injuries such as muscle strains may carry a risk of
14 reinjury regardless of time especially if there are residual deficits (e.g., reduced strength,
15 range of motion changes in the length-tension relationship) and structural damage (e.g.,
16 scar tissue) present several months after the initial injury (Bahr and Holme 2005;
17 Hägglund, Waldén, Bahr et al. 2005; Hägglund, Walden and Ekstrand 2006).

18 In studies in professional football, the severity of re-injuries is generally shown
19 to be significantly greater than that for the initial injury (Hawkins, Hulse, Wilkinson et
20 al. 2001; Waldén, Hägglund and Ekstrand, 2005a; Ekstrand, Hägglund and Waldén
21 2009). In contrast, the mean absence time for strain reoccurrences in the present study,
22 was similar to that reported for the original strain. This finding is in part accordance
23 with the findings of other research in professional football which reported no difference
24 in absence time for all types of injury and re-injuries (Waldén, Hägglund and Ekstrand,
25 2005b) and more specifically, that recurrent hamstring strains did not require a longer
26 absence than the original injuries (Woods, Hawkins, Maltby et al. 2004). These results

1 suggest that reoccurrence of muscle strain injuries may not be as greater 'setback' as
2 compared to other types of reinjury when returning to play. Nevertheless, the present
3 muscle strain reoccurrences required an absence of >1 week and in the region of 85
4 working days were lost (~3 days per player) and 11 matches missed per season,
5 highlighting the importance of avoiding strain re-injuries.

6 Strains to the hamstring region are the single most common type of injury at
7 professional levels in football (Ekstrand, Hägglund and Waldén 2009) and reoccurrence
8 of these injuries is frequent (Woods, Hawkins, Maltby et al. 2004). In the present study,
9 hamstring strains accounted for the major part of recurrent muscle strains and notably in
10 match-play. This may be a result of incomplete healing through inadequate
11 rehabilitation and/or too premature return to play with these factors linked to the
12 pressures of the contemporary game. Furthermore, the present findings showed
13 substantially higher rates of muscular strain reoccurrences in all body regions in
14 competition compared to training. This result is in contrast to the findings in other
15 investigations in professional football players (Hawkins and Fuller 2001; Hägglund,
16 Waldén and Ekstrand, 2009) which showed that the frequency of muscular strain re-
17 injuries during training was higher than in competition. However, in these previous
18 reports, rates of re-injury were presented as a simple percentage of the total number of
19 strain re-injuries and therefore did not take into account the effects of exposure time as
20 was the case in the present study. Nevertheless, both present and previous findings
21 reflect the risk of recurring strains during the rehabilitation process when players are
22 attempting to regain fitness especially as the major part of reoccurrences observed in
23 training in the present players occurred within 2-months after the original injury.

24 Of additional note was the considerable difference in strain reinjury rates across
25 playing positions notably in forward players and the high frequency of reoccurrences
26 reported in the hamstring region (~50%) in these players. This latter finding is in part

1 agreement with research conducted in English professional football players in which
2 forward players were also at high risk of sustaining a hamstring strain (Dadebo, White
3 & George 2004). The authors suggested that the high instantaneous speed demands
4 commonly observed in forward players are associated with a greater risk of incurring a
5 hamstring strain as these injuries occur when strong concentric quadriceps contractions
6 generate forces in sudden bursts of speed that the eccentric strength of the hamstrings
7 cannot withstand. While there is a general need for evidence-based prevention and
8 rehabilitation programmes for hamstrings strains (Peterson and Holmich 2005; Mason,
9 Dickens and Vail 2007; Goldman and Jones 2010), the present results also suggest the
10 need for programmes specifically tailored according to individual positional role.

11 Finally, the present study is the first to report data on the monthly distribution of
12 muscle strain reoccurrences across the playing season. The overall incidence of strain
13 reinjury peaked in May while rates were highest for match-play and training in
14 December and August/May respectively. This result suggests that in elite football
15 players, there is a risk of sustaining a reoccurrence of a muscle strain throughout the
16 playing season. In addition, the frequency of early and late recurrences of strains was
17 highest during the first two full months of the playing season (July and August) despite
18 systematic pre-season evaluation of lower-limb muscle strength and flexibility. While
19 muscle strains are common early in the competitive season in professional football
20 players (Woods, Hawkins, Hulse et al. 2002), the present findings suggest that a non
21 negligible part of these injuries may be reoccurrences of a previous strain carried on
22 from the previous season or one sustained during pre-season training. Therefore, these
23 results reinforce the need for adequate and complete rehabilitation programmes during
24 both the closed and pre-season periods.

25 A limitation of this study was that players from only one football club were
26 included and the patterns observed may only be a reflection of this particular club.

1 Similar investigations involving a larger sample of teams are required. In addition,
2 changes in the present club's coaching staff and practices over the study period may
3 have influenced these results. Furthermore, the first reported muscle strain over the
4 course of the study was used as the index injury (as done in previous studies that
5 reported data on football re-injuries). It is possible that this index injury was not the first
6 sustained by some players thereby some results may be confounded. Finally, the
7 incidence of muscle strains may be under- or over-estimated as exposure time in
8 training was calculated on a group basis and time spent by first-team players in
9 occasional reserve team competition was not included. Future research should also be
10 conducted to identify the specific muscles within regions (e.g. hamstring group) that are
11 commonly affected by strain re-occurrences which was not done in the present study.
12 Nevertheless, the strength of this investigation is its four-season span and prospective
13 nature. Furthermore, the methodology generally respects internationally recommended
14 injury recording systems specifically developed to evaluate re-injury in football
15 allowing the results to be compared to current and future research into muscle strain
16 reoccurrences.

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Table 1: Characteristics of muscle strains and muscle strain reoccurrences

Region	Muscle strains			Muscle strain reoccurrences		
	N° (%)	Incidence (95% CI)	Mean absence	N° (%)	Incidence (95% CI)	Mean absence
Hamstring	33 (22.9)	0.99 (CI 0.65-1.33)	8.7 ± 7.4	17 (38.6)	0.51 (CI 0.27-0.75)	7.5 ± 5.6
Quadriceps	32 (22.2)	0.96 (CI 0.63-1.29)	7.1 ± 4.1	6 (13.6)	0.18 (CI 0.14-0.32)	4.0 ± 1.9
Lower-leg	28 (19.4)	0.84 (CI 0.53-1.15)	5.4 ± 4.5	9 (20.5)	0.27 (CI 0.09-0.45)	8.2 ± 7.4
Groin	23 (16.0)	0.69 (CI 0.41-0.97)	8.8 ± 7.7	9 (20.5)	0.27 (CI 0.09-0.45)	9.1 ± 8.7
Abdomen	14 (9.7)	0.42 (CI 0.20-0.64)	7.6 ± 6.6	2 (4.5)	0.06 (CI -0.02-0.14)	8.0 ± 1.4
Pelvis	10 (6.9)	0.30 (CI 0.11-0.49)	9.6 ± 8.0	1 (2.3)	0.03 (CI -0.03-0.09)	2.0 ± 0.0
Back/Neck	4 (2.8)	0.12 (CI 0.00-0.24)	2.8 ± 0.5	0 (0.0)		
Total	144 (100)	4.31 (CI 3.61-5.01)	7.5 ± 6.4	44 (100)	1.32 (CI 0.93-1.71)	7.5 ± 6.3

Incidence = Number of injuries per 1000 hours exposure time.

95% CI = 95% Confidence Intervals.

Mean absence = Mean number of days according to the number of days the player was absent from and unable to take full part in training or competition.

Figure 1: Frequency of early reoccurrences of muscle strains sustained per week within a period of 8-weeks after the index injury.

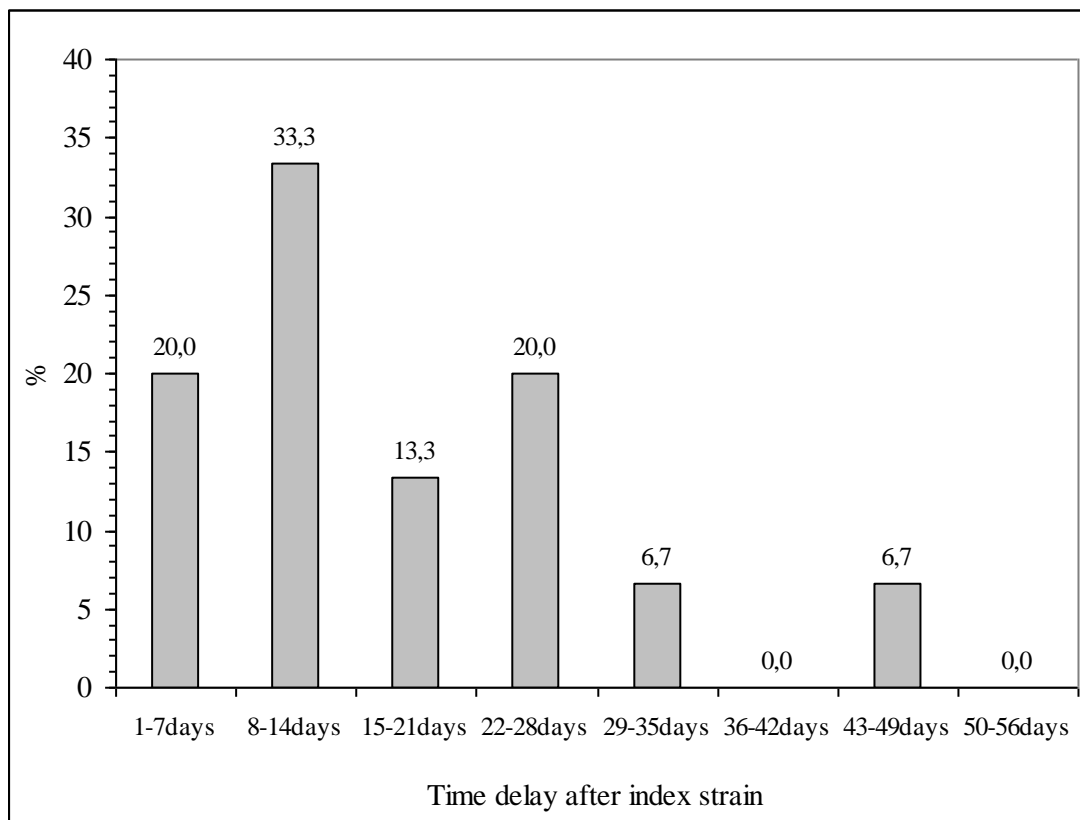
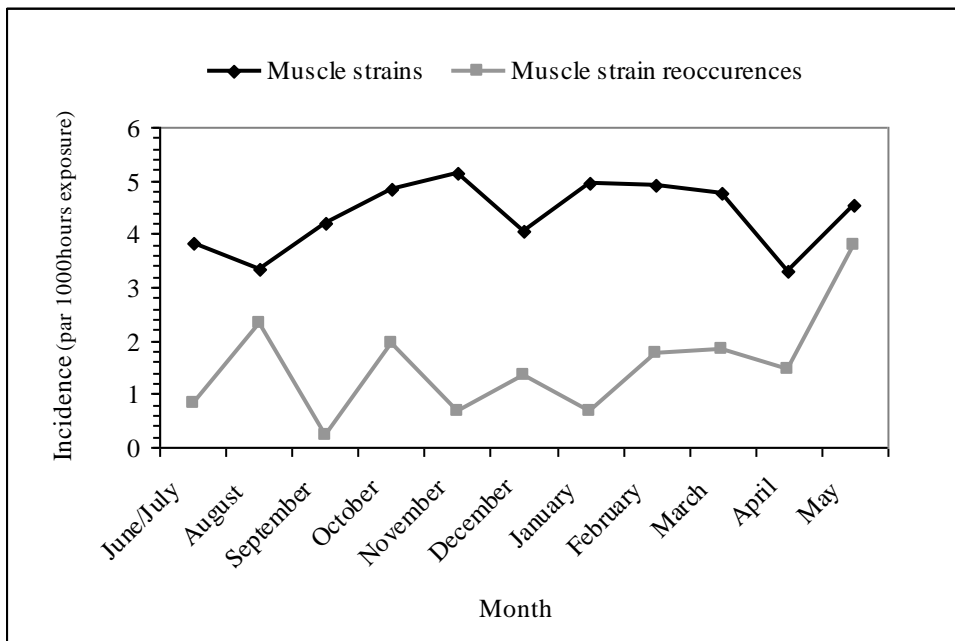


Figure 2: Seasonal distribution of muscle strains and muscle strain reoccurrences.



June/July = Pre-season training period and friendly matches.

August to May = Official competitive season including a two-week winter break in mid-December.