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Chapter 11

Muscle Injuries in Professional Soccer Players During the Month of Ramadan

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1. Introduction

The muscle injury risk is a major concern for soccer players and clubs in terms of health, safety, performance, and cost. Data in scientific literature must be made available through an effective muscle injury surveillance system, and knowledge of the factors that influence muscle injury is required. There is a need to identify the injury risks in soccer players and their respective dependent and independent variables, which are expected to differ in each specific population. Therefore epidemiological and etiological muscle injury data for international professional soccer need to be captured. The rates and characteristics of soccer muscle injuries during matches and training in top-level international tournaments such as English (Hawkins et al., 2001), Swedish (Hagglund et al., 2006), Norwegian (Andersen et al., 2004) league Championships, European Championships (Ekstrand et al., 2011) and World Cups (Dvorak et al., 2011) have been well documented; however only one study (Chamari et al., 2012) has focused on the muscle injury-rates of Muslim soccer players during the holy month of Ramadan. The first part of this chapter is dedicated to present muscle injury rates in soccer. The main aim of the present book chapter is presenting and discussing the muscle injury rate during the holy month of Ramadan its related possible causes. By providing a such analysis, it is hoped that this might help coaches and scientists to understand and choose a more efficient planning and manipulation of the player's internal training load during the Ramadan period in order to try to avoid muscles injuries.

2. Muscle injuries in soccer during traditional conditions

The first part of this chapter is dedicated to present muscle injury rates during matches and training sessions out of the month of Ramadan in English (Hawkins et al., 2001), Swedish

(Hagglund et al., 2006), Norwegian (Andersen et al., 2004) league Championships, European Championships (Ekstrand et al., 2011) and World Cups (Dvorak et al., 2011) in order to be able to further compare them with those found during the holy month of Ramadan.

Recently, Ekstrand et al., (2011) conducted a prospective cohort study in European Professional Soccer Players from 2001 to 2008. The study focused on seven consecutive seasons (July-May). In 2000, 14 teams from top European clubs (clubs participating at the highest level in Europe in the last decade) were selected by UEFA and invited to participate in the study of Ekstrand et al., (2011). Eleven teams agreed to participate and provided complete data for the 2001/2002 season. In the following seasons, 12 other teams were selected by UEFA and included in the study. Ekstrand et al., (2011) presented the results of the teams that have met the criteria for inclusion and comprehensive data sent over the full seasons. Table 1 shows these characteristics.

	All seven seasons	Seasons						
		2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Age	25.7 (4.4)	25.7 (4.4)	25.8 (4.0)	26.0 (4.3)	25.8 (4.1)	25.9 (4.5)	25.6 (4.6)	25.5 (4.6)
Training hours/ players	213 (71)	219 (66)	243 (64)	203 (67)	229 (65)	207 (75)	207 (75)	206 (68)
Exposure hours/ player	254 (85)	262 (80)	290 (74)	243 (80)	273 (79)	247 (89)	245 (90)	246 (83)
Match hours/ player	41 (23)	43 (22)	47 (23)	40 (24)	44 (24)	40 (23)	38 (24)	40 (24)
No of matches/ player	34 (17)	36 (16)	39 (16)	33 (17)	35 (16)	33 (17)	32 (17)	33 (17)
No of matches/ player	162 (53)	174 (53)	181 (45)	151 (47)	171 (46)	156 (55)	155 (56)	160 (52)
Values are mean (SD)								

Table 1. Characteristics of teams, players and exposure from 2001 to 2008 belonging from the best European clubs adapted from Ekstrand et al., (2011).

The authors reported 4483 injuries corresponding to 566 000 h of exposure (i.e, 475 000h of training and 91 000h of match-play) over the seven seasons, inducing a rate of 8.0 injuries / 1000 h. Muscle injuries were the highest type of injuries observed with 1581 injuries during the 566 000 h of exposure. A player performed an average of 34 games and had 162 training sessions each season (median values of 35 and 173, respectively). The overall average exposure during the football season was of 254 h, with 213 hours of training and 41 hours of games (median values being 269, 222 and 40, respectively). The rate of injuries during matches was higher than that of training (27.5 vs. 4.1, respectively, $p < 0.001$). The rates of muscle injuries and others types of injuries during training and the match remained steady during the 8-years with no significant difference in-between seasons.

A player may undergo on average two injuries per season, thus a team of typically 25 players can expect about 50 injuries each season. Table 2 shows the different types of injuries according to their severity with the top European clubs in according to Ekstrand et al., (2011). During the

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competitive season, traumatic (or contact) injuries and hamstring strains were the more frequent observed sport accidents, while during the pre-season, overuse injuries/muscle injuries were more frequently reported injuries (35.27% of all injuries during the seven years studied, Table 2). Recurrent injuries accounted for 12% of all injuries recorded during the seven successive studied seasons, causing longer absences than non-recurrent injuries (24 vs. 18 days, respectively, p <0.0001). In the same context, Hawkins et al., (2001) have shown that recurrent injuries represented 7% of 6030 injuries reported with 91 clubs in English Professional Football during two consecutive seasons.

	Total	1-3 Days	4-7 Days	ays	"/> 28 Days
Injury type					
Fracture	160 (4)	7	9	59 (4)	85 (12)
Other bone injury	26	5	1	6	14 (2)
Disloaction/subluxation	50 (1)	5	4	24 (1)	17 (2)
Sprain/ligament injury	828 (18)	123 (13)	197 (34)	334 (20)	174 (25)
Mensiscus/catilage	124 (Rejeski et al.)	3	7	41 (2)	73 (10)
Muscle injury/Strain	1581 (35)	212 (22)	397 (34)	765 (46)	207 (30)
Tendon injury	327 (7)	95 (10)	71 (6)	101 (6)	60 (9)
Haematoma/contusion	744 (17)	306 (32)	282 (24)	141 (9)	15 (2)
Abrasion	7	3	3	1	0
Laceration	31	10 (1)	11	10	0
Contusion	34	5	14 (1)	14	1
Nerve injury	29	7	3	14	5
Synovitis/effusion	158 (4)	55 (6)	36 (3)	55 (3)	12 (2)
Overuse complaints	285 (6)	110 (11)	99 (9)	59 (4)	17 (2)
Other type	91 (2)	23 (2)	27 (2)	24 (1)	17 (2)
Total injuries	**4483**	**971**	**1164**	**1651**	**697**

Values within brackets show percentage of total injuries (lower line - values below 1% not shown)

Table 2. Injury pattern by severity of injuries from 2001 to 2008 (rate: injuries/1000 h of exposure) with the best European clubs adapted from Ekstrand et al., (2011)

The rate of injuries during trainings and matches-play in the study reported Ekstrand et al., (2011) are consistent with the data of Hawkins et al., (2001), who reported A total of 6030 injuries collected over two seasons (i.e., from July 1997 through to the end of May 1999) with an average of 1.3 injuries per player per season of professional football in England. Table 3 shows the nature of the injuries sustained during training and matches reported by Hawkins et al., (2001). Muscles injuries represented 46% of all the injuries. The rate of muscle injuries in trainings was high than during matches-play (p<0.001). In Table 3, Injuries classified as "other" report back and nerve related pathologies/injuries, vertebral column-disc derangements, and non-specific pain, no individual category amounting to more than 0.5% of all injuries. It is of interest to note that the players' dominant side showed a greater sustained number of injuries compared with the non-dominant side (50% vs. 37%, respectively, p<0.01), and the lower limbs (including the groin) was the site of 87% of the total injuries reported (Table 3).

In the Swedish Premier League, Hagglünd et al., (2006) prospectively recorded individual exposure and loss of time due to injury over two full consecutive seasons (2001 and 2002). They showed that the rate of injuries and training match between the seasons were similar (5.1 vs. 5.3 injuries/1000 h of training and 25.9 vs. 22.7 injuries/1000 h of match-play; respectively) but the analysis of injury severity and injury patterns showed variations between seasons. In Norway, Andersen et al., (2004) collected data and videotapes of injuries prospectively during regular league matches in 2000 (April to October). Over 174 matches, 425 injuries were recorded: 1.2 injuries per team per match or 75.5 injuries per 1000 hours played. A total of 121 acute injuries were reported from game, giving a rate of 0.3 injuries per match and team or 21.5 injuries per 1000 hours played. In an analysis of the rates and characteristics of injuries in the edition of the 2010 FIFA World Cup, Dvorak et al., (2011) reported 229 injuries, of which 140 injuries requiring rest. The remaining injuries did not prevent the players to take part to the consecutive training sessions. In this study, 32 finalist squads participated (including 736 players). 82 injuries during matches and 58 injuries during training requiring rest were observed, resulting in a rate of 40.1 injuries/1000-h during matches (95% CI 31.4 to 48.8) and 4.4 injuries/1000-h during training (95% CI 3.3 to 5.5). Table 4 shows the Location and diagnosis of match and training injuries during this study.

Contact with another player caused by foul-play based on the judgment of the team physician was the most common cause of injuries during matches (65%) and training sessions (40%). These data showed that the most common diagnoses were contusions at the thigh and ankle sprain (Dvorak et al., 2011). In the same context, Ekstrand et al., (2011) showed that 21% (n = 538) of all injuries recorded during matches of seven successive seasons with the best professional players were due to foul-play according to the referee, with the majority being due to foul play by an opponent (n=520). The most common foul-play injuries were ankle sprains (15%), knee sprains (9%) and thigh contusions (10%). In the two studied seasons, (2006/07 and 2007/08), the match timing of injury showed that foul-play injuries were evenly distributed among the two halves (74 vs. 84 for first and second half, respectively, p=0.47). In this context, receiving a tackle, receiving a ''charge'', and making a tackle were categorized as associated with a substantial injury risk, while goal punching, kicking the ball, shot on goal, set kick, and heading the ball were all categorized as exposing to a significant injury risk. With respect to match minute, Injury risk was highest in the first and last 15 minutes of the games. This probably reflects the intense engagements in the opening period of each game, during which the players are highly motivated and the effects of fatigue not yet clearly observable, and the possible effect of fatigue in the closing period. The injury risk was also concentrated in the areas of challenge where possession of the ball is the most hotly contested, i.e., the attack and defense areas near the goals. The injury rate during the 2010 FIFA World Cup was lower than in the previous three World Cups (Dvorak et al., 2011) as presented in Table 2. This may be a result of a connection to additional injury prevention, and a reduced fool play probably due to the more stringent arbitration (Dvorak et al., 2011). Dvorak et al., (2011) showed that training injuries differed substantially from match injuries with respect to diagnosis (Table 4) and cause, but not in severity. It was reported that training injuries were more often as a result of overuse and non-contact trauma than match injuries. In this context, it is interesting to note that 12 out of 104 training injuries were reported to be contact-injuries caused by foul-play. Out of these 12 injuries, 6 were reported from one team. In this case the rate of time-loss training injuries was similar to those reported for the European Championships {i.e., 1.3–3.9 per 1000 hours of exposure to Training} (Hagglund et al., 2006; Ekstrand et al., 2011).

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	All injuries		Competition injuries		Training injuries	
No	**%**	**No**	**%**	**No**	**%**	
Nature of injury						
Muscular strain/rupture	*2225*	*37*	*1322*	*35*	*859†*	*42*
Ligamentous sprain/rupture	1153	19	765	20	370	18
Muscular contusion	*431*	*7*	*343*	*9*	*79†*	*4*
Tissue bruising	336	6	263	7	64†	3
Fracture	253	4	186	5	61†	3
Other	238	4	123	3	95†	5
Tendinitus	237	4	107	3	10†	5
Inflammatory synovitis	192	3	114	3	73	4
Mensiscal tear	148	2	80	2	63‡	3
Hernia	120	2	56	1	40	2
Overuse	*108*	*2*	*44*	*1*	*44†*	*2*
Dislocation	81	1	50	1	28	1
Periostitis	75	1	52	1	23	1
Cut	73	1	60	2	13†	1
Chondral lesion	69	1	41	1	24	1
Capsular tear	54	1	47	1	6†	0
Paratendinitis	46	1	17	0	27†	1
Bursitis	29	1	10	0	18†	1
Blister	6	0	2	0	4	0
Skin abrasion	3	3	2	0	1	0
Not classified	153	101	96	3	44	2
Total*	6030		3780	98	2046	99
Location of injury						
Thigh	1388	23	889	24	468	22
Knee	1014	17	610	17	355	16
Ankle	1011	17	682	19	304†	14
Lower leg	753	12	452	12	272	13
Groin	596	10	226	6	340†	16
Neck/spine	352	6	176	5	159†	7
Foot	302	5	202	6	94	4
Upper limb	153	3	99	3	50	2
Hip	135	2	82	2	46	2
Abdomen	90	1	50	1	36	2
Chest	86	1	77	2	7†	0
Head	67	1	55	2	11†	1
Toe	63	1	50	1	12†	1
Other	15	0	12	0	1	0
Not specified	5	0	4	0	1	0
Total*	6030	99	3666	100	2160	100

* Percentage totals may subject to rounding errors associated with individual components

† $p<0.01$ Different proportions between training and competition

‡ $p<0.05$ Different proportions between training and competition

Table 3. Nature and location of injuries sustained during match-play and training with 91 professional soccer clubs in England during two consecutive seasons adapted from Hawkins et al., (2001).

Location and diagnostics	Match injuries		Training injuries	
	All	With absence	All	With absence
Head/neck	13	4	6	3
Contusion	1	1	1	0
Contusion	4	1	2	0
Muscle cramps (neck)	0	0	2	0
Upper extremity	12	6	4	2
Fracture	1	0	0	2
Sprain	4	3	0	0
Contusion	4	3	1	0
Laceration	0	0	1	0
Trunk	8	5	10	4
Contusion	5	2	3	0
Sprain/strain	2	2	1	1
Hip	2	1	1	1
Contusion	1	0	0	0
Groin	4	4	3	3
Muscle strain	3	3	1	1
Tendonitis	1	1	1	1
Muscle cramps	0	0	1	1
Thigh	36	25	19	13
Muscle strain/rupture	11	10	11	9
Contusion	12	6	2	1
Muscle cramps/tightness	9	7	3	2
Knee	9	6	16	9
Sprain	4	3	3	3
Tendinopathy	0	0	2	1
Contusion	3	1	4	1
Lower leg	19	12	18	9
Muscle strain/rupture	6	5	2	1
Contusion	11	5	9	2
Muscle cramps	0	0	2	2
Ankle	15	12	17	8
Sprain	6	4*	12	8*
Contusion	7	6	5	0*
Foot	7	7	10	6
Contusion	6	6	6	3

* Information was missing for at least one injury.

Table 4. Location and diagnosis of match and training muscle injuries (n=229) in 2001 in the Norway professional soccer season adapted from Dvorak et al., (2011).

Years		1998	2002	2006	2010
Injuries per match	all injuries	2.4	2.7	2.3	2
	time-loss injuries	0	1.7	1.5	1.3

Table 5. Average number of injuries per match in FIFA World Cups 1998–2010 (grey: all injuries; black: time-loss injuries) adapted from Dvorak et al., (2011).

Muscle injury risk can also be affected by the match schedule. Indeed, Dupont et al., (2011) showed that the muscle injury rate can be much higher when 2 matches are played during the week, compared to classical one-game per week schedule. The highest muscle injury was located at thigh (32 vs 15 injuries, respectively. These results confirmed that insufficient recovery between matches leads to fatigue and increases the risk of muscle injury. In the 2006 World-Cup (Germany), Dvorak et al., (2007) reported an injury rate slightly lower than the results of Dupont et al., (2011). In this tournament, the high rate of injuries may have been linked to the limited number of recovering days between 2 matches (given that most matches were played every 3 to 5 days) and the repetition of matches in a congested fixture schedule. Although some of the players studied probably had more than 4-days recovery between matches, this result highlights the higher risk of muscle injuries when the recovery between 2 matches is short. In this context, Ekstrand et al., (2004) reported that a congested soccer calendar increased the risk of muscle injury or underperformance. Results from these afore-mentioned studies confirm the high risk of injury during a congested calendar. Nevertheless, conflicting results come from Carling et al., (2012) who did not observe any difference in the injury rate between congested fixture period and outside such a period. In the same context, recently with a higher number of matches, Dellal et al., (Accepted 2012) showed that muscle injuries during the congested periods of fixture (3 different congested fixture periods, 6 matches in 21 days during each one of the congested periods) was not different to those reported in matches outside these periods (55.8% of total injuries from 14.4 injuries/1000h during congested period vs 55.6% from 15.6 injuries/1000h during non-congested period). Rahnama et al., (2002) assessed the exposure of English Premier League players to injury risk during the ''1999–2000 season'' by rating the injury potential of playing actions during competition with respect to the type of playing action, period of the game, zone of the pitch, and playing either at home or away games. Muscle injury rate was no different in away matches than at home games (Rahnama et al., 2002). From the 3836 injuries for which the timing of injury was known, Hawkins et al., (2001) found that a greater than the average frequency of injuries was observed during the final 15 minutes of the first half and the final 30 minutes of the second ($p<0.01$). Table 6 shows the distribution of the competitive match injuries with respect to timing of occurrence. Despite the increase in injury rate observed towards the later stages of the first half (i.e. the last 15 min of play, which was similar with the same trend for the second half), overall, there remained a greater number of injuries recorded in the second half compared to the first (57% *v* 43%, respectively, $p<0.01$). This may be the result of fatigue of the muscles and other body organs as well as muscle glycogen stores near to depletion (Reilly, 1997) and players becoming hypo-hydrated (Saltin, 1973).

Time (minutes)	Injuries (%)
0 – 15	8
>15 – 30	14.5
>30 – 45	22.5
>45 – 60	10
>60 – 75	19
>75 – 90	26
Total	100

Table 6. Timing of occurrence of injuries in matches with 91 English professional soccer clubs during two consecutive sessions adapted from Hawkins et al., (2001).

There is evidence to suggest that fatigue is associated with muscle injury. Indeed, empirical observations have shown that fatigued individuals are susceptible to muscle injury [See for review (Schlabach, 1994)]. Fatigue may not be the only cause of muscle injury, but rather a contributing factor. After reviewing the literature regarding the etiology of muscle injuries, Worrell and Perrin (1992) reported that fatigue was one of several factors that may contribute to frequency of hamstring strains (one of the common muscle injuries in soccer).

Since muscle glycogen depletion is associated with fatigue and possibly injury, it should also be treated as a potential risk factor. Muscle glycogen stores are almost entirely derived from carbohydrate intake. Both indirect and direct evidence support the notion that depleted muscle glycogen stores contribute to muscle injury. Indirectly, it is quite clear that depleted muscle glycogen stores coincide with fatigue, and fatigue in turn is associated with muscle injury as mentioned above. Although most of the evidence involves relationships rather than showing cause, many of the investigations strongly suggest a cause-and-effect relationship between low muscle glycogen stores and injury risks [See for review (Schlabach, 1994)]. Depletion up to 84-90% of intramuscular glycogen stores has been observed in soccer players at the end of a soccer match (Jacobs et al., 1982). Soccer players with low glycogen stores at the start of a match had almost no glycogen left in their working muscle and physical performance of these players decreased in the second half in comparison to those players with higher pre-game and halftime glycogen muscle levels (Jacobs et al., 1982). Because there is a limited capacity to store muscle glycogen, and because muscle glycogen is the predominant fuel in exercise of moderate to severe intensity, the nutritional focus should be on carbohydrate consumption [See for review (Schlabach, 1994)]. The absolute amount of carbohydrates in the diet may be an important factor for the recovery of muscle and liver glycogen stores after training and competition (Ivy, 2001). In this context, it is important to mention that an inadequate nutrient intake and hypo-

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hydration could affect the physical performance of the athlete and possibly contribute to sports injuries (Convertino et al., 1996). Large sweat losses, insufficient fluid intake, and consequent fluid deficits could likely impair performance and may increase the risk of hyperthermia and related problems (Bergeron et al., 2005), stressing the importance of appropriate hydration before training and matches in soccer players. In this context, as ending the day dehydrated, fasting players (as observed during Ramadan) could be exposed to higher risks of muscle injury.

Another important cause related with fatigue-associated injuries is the sleeping duration and/or quality. Research indicates a relationship between sleep deprivation and decreased performance in adults (Taylor et al., 1997; Belenky et al., 2003). Recently, Luke et al., (2011) confirmed that fatigue-related injuries were related to sleeping less than 6 hours the night before the injury (p = 0.028) among athletes aged 6 to 18 years. In contrast, Luke et al., (2011) have reported no difference in the average amount of sleeping hours or reported sleep-deprivation between the overuse and acute injury groups of their study. However, with evidence of the obvious contributing role of fatigue in increasing muscle injury risk, planning for adequate sleep before and during training or competition events should be another notable consideration in determining a player's training schedule and setting-up an event schedule, especially if travel is involved. As sleeping schedule is acutely changed during Ramadan, this month could be a cause of higher muscle injury risks for athletes.

3. Muscle injuries in soccer during Ramadan period

Investigations describing muscle injury risk and muscle injury patterns in soccer are usually conducted over seasons of European or American Leagues (Andersen et al., 2004; Ekstrand et al., 2011; Dupont et al., 2011). To our knowledge, only one study (Chamari et al., 2012) has focused on the injury-rates of muslim soccer players during the holy month of Ramadan. In this context, to our knowledge this is the only scientific publication having studied the effect of Ramadan fasting on sports' injuries.

3.1. Ramadan characteristics

During the wholly month of Ramadan, fasting Muslims do not eat, drink, smoke, or have sexual activities daily from dawn to sunset. Since the Islamic Calendar is based on the lunar cycle, which advances 11-days compared with the seasonal year, Ramadan occurs at different times of the seasonal year over a 33-year cycle (Chaouachi et al., 2009a). This implies that Ramadan occurs at different environmental conditions between years in the same country (Leiper et al., 2003; Leiper et al., 2008). It is supposed that most Muslim soccer players fast during Ramadan, even if some exceptions are observed. Ramadan fasting is intermittent in nature, and there is no restriction to the amount of food or fluid that can be consumed after dusk and before dawn. Therefore, since the international sporting calendar is not adapted for religious observances, and Muslim soccer players continue to compete and train during Ramadan, various studies have determined whether this religious fast has any effect on athletic performance (Chaouachi et al., 2009a) and cognitive functions (Maughan et al., 2010; Waterhouse, 2010). These have suggested that only few aspects of physical fitness are negatively affected, and only modest decrements are observed when physical performance is considered on the basis of fitness testing (Chaouachi et al., 2009a). The evidence to date indicates that high-level athletes can maintain most of the performance measures during Ramadan if physical training, diet, and sleep are well controlled. Nevertheless, despite this, fasting athletes report higher fatigue feelings at the end of Ramadan (Chaouachi et al., 2009a; Güvenç, 2011). This could have a possible effect on performance of injury during or at the end of the month of Ramadan.

The increased perception of fatigue reported at the end of Ramadan fasting and the combination of intense training with altered carbohydrate intake, hydration-status, and sleeping pattern may place fasting Muslim athletes at greater risk of overreaching or overtraining (Chaouachi et al., 2009b; Chaouachi et al., 2009c) which could result in physical injury specifically overuse injuries (Johnson and Thiese, 1992). Most previous studies determined whether the holy month of Ramadan has any detrimental effect on performance and cognitive functions, but to our knowledge, only the study of Chamari et al., (2012) has examined the impact of the month of Ramadan and its specific socio-cultural and religious environment on the injury rates of professional elite soccer players. This pilot study presented some results on the injury rates between fasting and non-fasting players within a team before, during, and after the month of Ramadan in a professional football team during two consecutive seasons.

3.2. Muscle injury rates during Ramadan

The study of Chamari et al., (2012) presented some results on the muscle injury rate between fasting and non-fasting players within a professional soccer team during the month of Ramadan during two consecutive seasons. Ramadan occurred from 10 August to 11 September 2010 and from 1 to 30 August 2011, respectively, where the daily fast occurred from ~04 h to ~19.15 h, for a total duration of ~15h15min fasting duration. In this study, training loads (using the RPE-method), Hooper index (Hooper and Mackinnon, 1995a) {i.e., Sum of well-being subjective ratings relative to fatigue, stress, delayed onset muscle soreness (especially "heavy" legs), and sleep quality/disorders} and muscle injury were monitored in 42 professional soccer players (Age, 24 ± 4 years; height, 185 ± 8 cm; body mass, 78 ± 4 kg) a month before Ramadan, the month of Ramadan, and the month after Ramadan during each season. Injury data were considered when a player was unable to take full part in future soccer training sessions or matches owing to physical complaints (Fuller et al., 2006). Information about mechanism of injury (traumatic or muscle injury) and circumstances (training or match injury) were documented. Before and after Ramadan the sessions and matches were scheduled in the afternoon (starting at 15 or 16h) and sometimes in the morning for training (for the days in which 2 training sessions were scheduled, starting at 09.30 h) while during Ramadan, training sessions and matches were performed after dusk (starting at 22h). Ambient temperature, atmospheric pressure and relative humidity were measured for each training session and are presented in Table 7.

	Year	Ambient Temperature (C°)	Atmospheric Pressure (mmHg)	Relative Humidity (%)
Before Ramadan	2010	28.83 (1.72)	1012.33 (2.25)	44.00 (5.02)
	2011	31.31 (5.38)	1011.38 (3.10)	39.15 (13.61)
Ramadan	2010	27.60 (4.04)	1014.20 (2.05)	55.80 (8.44)
	2011	24.50 (1.29)	1014.50 (2.65)	64.50 (6.56)
After Ramadan	2010	25.25 (2.06)	1014.00 (3.83)	61.50 (8.66)
	2011	28.50 (1.29)	1013.25 (3.10)	63.25 (8.54)

Values are mean (SD)

Table 7. Ambient Temperature, Atmospheric Pressure and Relative Humidity for the months of Ramadan, Before Ramadan and After Ramadan, reported by Chamari et al., (2012).

Chamari et al., (2012) have shown that muscle injuries were lower during the months prior to- and after-Ramadan with only 22.22% of total muscle injuries in both cases, while this type of injury (i.e., muscle injury) dramatically increased during Ramadan with 84.21% out of total injuries observed for the two months of Ramadan monitored. For these two periods of Ramadan (Chamari et al., 2012), the muscle injuries were distributed as follows: muscle spasms (contractures) 43.75%, tendinopathy 43.75%, and muscle strains (one tear at the hamstrings and one strain at the thigh-adductors) 12.5%. The 7 contractures were located at the hamstrings (42.86%), calf muscles (28.57%), thigh-adductors (14.29%), and knee extensors (14.29%). The tendinopathy injuries were located at the thigh-adductors (42.86%) and foot quadriceps (14.29%), with the remaining tendinopathy injuries (42.86%) located at the abdomen and pelvis. The foremost result of the study of Chamari et al., (2012) was the absence of significant difference between non-fasting and fasting players with regard to general injury rates, while the training muscle injury rates were significantly higher during Ramadan than before and after-Ramadan periods for the fasting players (Table 8).

	Before Ramadan ⁺		Ramadan ⁺		After Ramadan ⁺	
	Fasting	Non-Fasting	Fasting	Non-Fasting	Fasting	Non-Fasting
Rate of muscle injury during matches	0 (-1.3-1.3)	0 (-1.3-1.3)	1.2 (-0.1-2.4)	0 (-1.3-1.3)	0.5 (-0.7-1.8)	0 (-1.3-1.3)
Rate of muscle injury during training	0.6 (-1.1-2.2)	0.6 (-1.1-2.2)	5.6 ᵇ (4.0-7.2)	3.2 (1.5-4.8)	0.5 (-1.1-2.2)	0 (-1.6-1.6)

⁺ each period consisted of 4 weeks respectively in each of the two studied seasons.

ᵇ significantly higher than before and after-Ramadan.

Note: values in bracket are 95% confidence intervals.

Table 8. Comparisons of muscle injury rates in fasters and non-fasters for the two monitored seasons (adapted from Chamari et al., 2012).

The rates reported during the month of Ramadan (Chamari et al., 2012) were consistent with data found in Union of European Football Associations {UEFA} (Ekstrand et al., 2011), English Premier League (Hawkins et al., 2001), Swedish Premier League (Hagglund et al., 2006), Scottish league (Dupont et al., 2011), and Norwegian league (Andersen et al., 2004). Nevertheless, the muscle injury rate of the study of Chamari et al., (2012) outside the month of Ramadan is lower than what is typically reported in the literature. It has to be stressed by the authors that this muscle injury rate concerns pre-season and the start of the season and this might explain these lower rates. Indeed, pre-season is characterized by a high prevalence of endurance training and fitness training which were performed in a progressive manner. The low frequency of matches at these stages might be the cause of the low overall injury rates of the studied periods (Chamari et al., 2012). Indeed, it has been well demonstrated (as mentioned above in the present book chapter) that the match injury rates are always much higher than the training injury rates (Ekstrand et al., 2011). In this context, Koutedakis and Sharp (1998) showed that the preparation phase of the season is accompanied with fewer injuries than the competition phase. Despite a higher mean overall injury rate during the Ramadan months of the 2 studied seasons (Chamari et al., 2012), i.e. 12.3 injuries/1000-h exposure, vs 4.9 for the month's before-Ramadan and 6.7 for the month's after-Ramadan, the difference between non-fasting and fasting players being not significant, while the rate of muscle injuries during training was significantly higher during Ramadan than before- and after-Ramadan in fasting players (Table 8). Nevertheless, these groups showed differences for the Hooper's Index and perceived stress (Hooper and Mackinnon, 1995b) with fasting players having lower Hooper's Index and stress during Ramadan and after Ramadan than non-fasting players. Moreover, no difference was observed between fasting and non-fasting players for the reported quality of sleep, and quantity of delayed onset muscle soreness and fatigue during Ramadan, before, and after-Ramadan (Figure 1).

Despite the difference in Hooper Index observed, Chamari et al., (2012) showed that training load, training strain, and training duration were maintained during the 3 periods and between groups for the 2 monitored seasons (Figure 2). The technical staffs of this study (Chamari et al., 2012) had not decrease training load during Ramadan based on the key findings of Chaouachi et al., (2009a) who has suggested that elite athletes could avoid steep decrements in their physical capacities while undergoing the intermittent fast of Ramadan, when they were maintaining their usual training loads; However, although there is no study contrasting the suggestions of Chaouachi et al., (2009a), technical staffs should adapt the training load of their players based on daily observations. The suggestion of Chaouachi et al., (2009a) concerned players from elite Tunisian athletes with different characteristics of training compared to European top-level teams. Indeed, in Tunisia, there are less frequencies of matches than in European top-class teams with games played each 3-4 days almost continuously for about 10 months (about 25 to 40 games vs. 45-62 games, respectively). Another concern with Ramadan in Europe comes from the daylight duration. Indeed, fasters in Europe abstain from food and fluids for 1 to 2 hours longer than Tunisia in summer for example. In summer, with the relative heat, this could be a challenge for Muslim Fasters that are part of a European Team in which technical staffs have objectives of performance and hence, do not even think about managing the training pattern. The study of Chamari et al., (2012) reported data of players that trained

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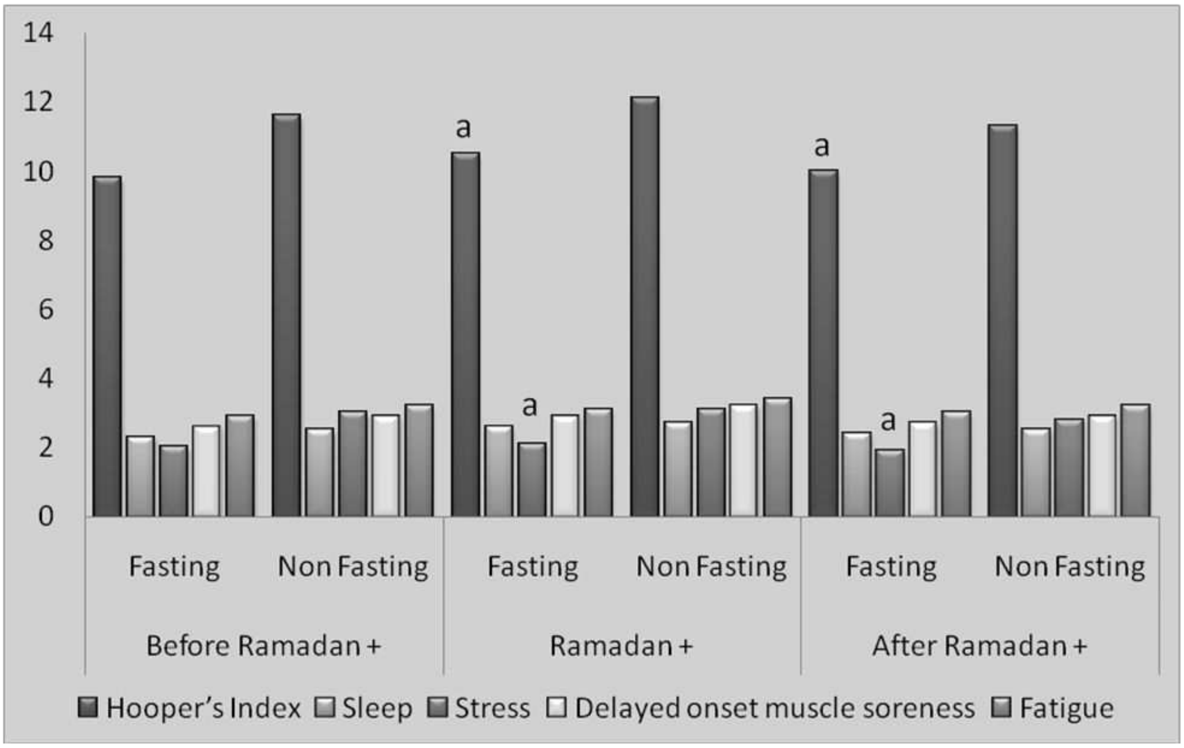


[+] each period consisted of 4 weeks in each year, respectively.
[a] significant different from non-fasting players at $p<0.05$.

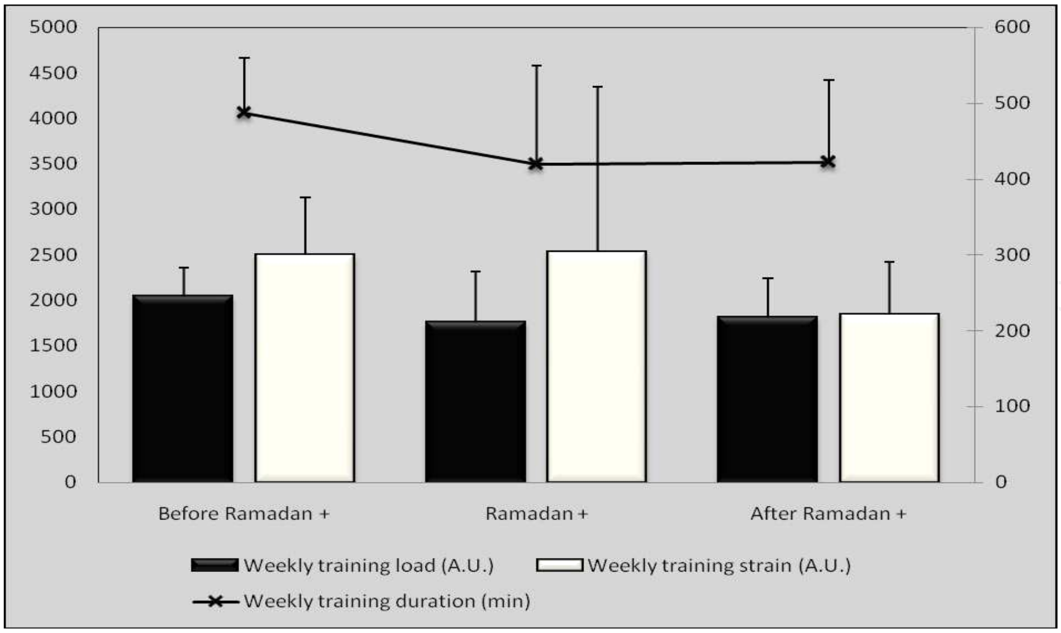
Figure 1. Comparisons of Hooper Index, (sleep, stress, delayed onset muscle soreness, and fatigue) {means of the 2 studied seasons} (Chamari et al., 2012).

at night during Ramadan and avoiding days including two training sessions. Consequently, their conclusions are not adaptable to such specific European Fasting players keeping training during the day (often in the morning and with some double sessions' days) and having to keep off their food and fluid intakes that are one of the pillars of recovery. Ending a high load training session at around 11h00 a.m. and having to keeping on fasting for the remaining hours until the sunset (Iftar) certainly presents a challenge, especially for the long daylight days (i.e., summer). Adding a second training session in the afternoon, is certainly not easy at all. Some recommendations in that regard have been made by Kirkendall et al., (2012) in trying to advise the technical staffs and athletes to deal with training during Ramadan. In this regard, further studies on injuries during Ramadan in different parts of the world, and through the year calendar are needed. Other specific situations should also be investigated as some players chose to fast during the week but not the day of the games. This surely presents another pattern of fasting with specific physiological adaptations and therefore injury pattern.

3.3. Possible causes of muscle injuries during Ramadan

3.3.1. Sleep disturbance and consequences

The study Chamari et al., (2012) have shown that the perceived quality of sleep was not significantly different between the months of Ramadan and the months before and after



+ each period consisted of 4 weeks respectively in each season.
A.U.: arbitrary units

Figure 2. Comparisons of weekly training load, strain, and duration {mean of the 2 studied seasons} (Chamari et al., 2012).

Ramadan. Even if the reported quality of overall sleep was not altered during Ramadan, the sleeping scheduling was greatly modified with players not going to bed before 03.00-h a.m. (Chamari et al., 2012). Recently, Luke et al., (2011) showed that sleeping less than 6-h the night before the injury occurrence was associated with increased fatigue-related injuries. The results of the study of Chamari et al., (2012) show no influence of Ramadan on the perceived sleep quality of the participants. As the Hooper's index is a simple general index aiming to assess sleep quality, the absence of change does not necessary mean that sleep architecture was not altered. Even if the participants were generally satisfied about their whole 24-h sleeping quality, it may be that the time spent in the different sleeping phases was modified. In this context, it has been well established that sleeping architecture is characterized by different phases at the beginning and the end of the night (Czeisler et al., 1980; Duffy et al., 1996). The change in the sleeping and nutritional habits during Ramadan (i.e. much less night-sleep and more afternoon naps for fasters and non-fasters and major changes in eating patterns for the fasting players) may have altered the players' physiological status during Ramadan, probably leading to the observed higher over-use injury rate during the fasting month (Bogdan et al., 2001; Montelpare et al., 1992; Reilly and Waterhouse, 2007).

3.3.2. Physiological and hormonal disturbances

After sleeping architecture disturbances, an additional probable cause of higher overuse injuries could also be the end-of-Ramadan state of the fasting players. In this context, Chaouachi et al., (2009c) have clearly shown that elite athletes continuing to complete high training loads during Ramadan might endure higher levels of fatigue and are likely to experience a cascade of small biochemical adjustments including hormonal, immunoglobulin, and antioxidant system changes, and an elevated inflammatory response. These variations are close to what is observed in tissue traumatic processes as found in athletes in state of over-reaching or overtraining (Chaouachi et al., 2009c). Although the variations are small and may not be considered clinically relevant, they may still signal physiological stress (Chaouachi et al., 2009c). In this context, the overtraining syndrome has been referred as staleness or chronic fatigue with a mental lassitude along with some associated injuries that are observed in parallel to a significant decline in physical performance (Kenttä and Hassmén, 1998; Halson and Jeukendrup, 2004). Overtraining affects the musculoskeletal system in that sense that serum creatine kinase levels are increased and enzymatic markers of muscle tissue injury significantly elevated the day after high training loads. It is unclear whether the observed over-use injuries observed in the over-trained or over-reached athlete could be the result of excessively high training loads and/or the impaired ability to recover from training. As training load was not different between fasters and non fasters in the study of Chamari et al., (2012), it is possible that the recovery processes could be altered by Ramadan intermittent fasting.

3.3.3. Psychological alteration and general fatigue

Contradictory with many studies [see for review (Chaouachi et al., 2009a] showing that Ramadan induces additional stress on the athlete, the perceived mental stress assessed by the Hooper scale during Ramadan in the study of Chamari et al., (2012) was not different from stress measured before and after Ramadan for non-fasting players. Rather, the fasting players reported decreased stress for Ramadan and for the month after-Ramadan compared to pre-Ramadan month. It could be speculated that the religious beliefs and the well-being of living and practicing a holy month, could have led to a lower perception of stress in the latter players. The possible habituation process in the fasting players has also to be considered, as they reported that they had fasted and trained simultaneously for a mean period of seven years and thus the absence of total injury risk with respect to the non-fasting players relates to habituated fasters. Newly fasting players' data are not available from the study of Chamari et al., (2012).

3.3.4. Contextual conditions

The period of the year and changing climate has to be considered with respect to the effect of Ramadan on the incidence of sporting injuries. Indeed, the study of Chamari et al., (2012) was conducted over the 2010 and 2011 years with the months of Ramadan occurring in August/September in Tunisia where daily fasting lasted about 15h15min and the temperature was relatively high. Different fasting periods and environmental conditions have to be experimented with respect to their effects on professional soccer players' injury rates. It has also to be noted that in the latter study the training sessions occurred during the nights (22h00, i.e. about 3 hours after the ''iftar'' / fasting break). In that sense, the injury rates reported concern therefore ''Fasting'' players that were not in a fasting state, as they did break the fast about three hours earlier and were allowed to drink ad-libitum before and during the training sessions and games. Unfortunately, no data is yet available for any injury rate occurring in fasting players during training or matches.

4. Recommendations and conclusion

The only study in scientific literature (Chamari et al., 2012) on the muscle and general injury rate during the month of Ramadan was conducted in professional football players shows that many changes occurring during the Ramadan fasting may potentially affect the muscle injury risk for fasting players. In Muslim majority countries, non-fasting players may also be affected by changes in eating and sleeping habits and in the scheduling of training and match play. Preliminary data of Chamari et al., (2012), however, show the absence of the effect of the holy month of Ramadan on the general injury rates of fasting and non-fasting elite soccer players where weekly training loads were maintained during Ramadan. However, rates of non-contact injuries and rates of muscle injuries during training were higher during Ramadan than before or after Ramadan in fasting compared to the non-fasting players.

Therefore, it appears that coaches and medical staffs involved in the management of fasting players should monitor and adapt the training load according to the timing of Ramadan on the year's span (environmental conditions), and the culture and the level of the players. Pay special attention to the recovery interventions (rest, nutrition, and hydration).

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