Original article

Reducing muscle injuries and reinjuries in one italian professional male soccer team

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Summary

***Background*. The incidence rate of muscle injuries and re-injuries in professional elite soccer players actually is very high and may interfere with the fate of a championship.**
***Purpose*. To investigate the effect of a two-tiered injury prevention programme on first injury and re-injury incidence in top level male soccer players.**
Study design
***Case Series Study*. Muscle injuries and re-injuries sustained by a group of 36 soccer player of an italian elite soccer team have been collected during 2010-2011 season. These data have been compared with those collected during the previous season in the same elite soccer team.**
***Results*. A total of 64 injuries occurred, 36 (56%) of which during practice and 28 (44%) during matches. Muscle injuries accounted for 31.3% of the total (n=20), 70% (n=14) of which occurred during practice and 30% (n=6) during matches. Hamstring were the muscles most often injured (n=11) In all, 3 re-injuries occurred (15% of muscle injuries). No early re-injuries occurred. The incidence was 2.5 injuries/1000 hours and the burden was 37 days absence/1000 hours.**
***Conclusions*. Through the implementation of a group and personalized injury prevention program, we were able to reduce the total number of muscle injuries and days absent because of injury, in a team of elite soccer players, as compared to the previous season. Specifically, muscle injuries accounted for 31% of all injuries, as compared to 59% of all injuries sustained by the team during the previous season. The number of injuries/1000 hours of exposure was reduced by half (from 5.6 to 2.5) and the days absent/1000 hours fell from 106 to 37.**

KEY WORDS: muscle injuries, football, prevention.

Introduction

Muscle injuries are a major problem in both amateur and professional soccer[1-3]. In a recent epidemiological study in elite soccer players, Ekstrand et al.[4] found that muscle injuries account for over 30% of total injuries and for about 25% of absence from playing time. Treatment of such injuries is especially problematic and often a frustrating challenge for the sports physician. Under pressure from elite sports clubs, the medical staff may permit the player's return to competition before the injury has healed completely, setting the stage for recurrence, with prolonged absence of the player from competition and training and considerable economic loss for the club[5].
There is a sizable literature on the epidemiology of sports injuries, established protocols for treating muscle injuries[6-10] and assessment criteria for imaging, clinical and functional tests that can aid the medical staff in deciding the optimal point at which an athlete can be safely returned to full participation[10-11]. However, current guidelines have not translated into a significant reduction in muscle injury rates in professional sports. Furthermore, a new injury often occurs within a few weeks after return to competition and typically costs the athlete more playing time than the primary injury[12,13].
Ekstrand defined early recurrence as "an injury of the same type and at the same site as an index injury occurring no more than 1 month after a player's return to full participation from the index injury[14]." A recent epi-

Muscles, Ligaments and Tendons Journal 2013; 3 (4): 324-330

demiological study involving elite soccer players estimated that recurrence accounts for 16% of all muscle injuries [4]. One of the most commonly cited risk factors for leg injuries is a previous injury of the same type and at the same anatomical site[15-19].
Further predisposing the athlete to recurrence are other risk factors associated with anatomical alterations following the index injury, including muscle tightness or weakness, scar tissue formation, biomechanical alterations, neuromuscular inhibition, as well as inadequate treatment such as too aggressive or incomplete rehabilitation and underestimation of extent of injury[20-22]. There is a wealth of literature on the efficacy of methods to prevent muscle injury and injury recurrence (concentric and eccentric exercises, recovery of flexibility, anaerobic interval training, and sport-specific training drills) [23-27]. Yet the prevalence of muscle injuries, and the recurrence rate in particular, remains alarmingly high[14-20].
The injury prevention program entitled "The 11", developed with the support of the Federation Internationale de Football Association (FIFA), encompasses different exercises that aim to improve technique and motor control during standing, cutting, jumping, running, planting, and landing, and has been shown to be effective in preventing injuries in female soccer players. Although the program was found to be effective in preventing knee injuries, it not was found to be effective in preventing anterior thigh, posterior thigh (hamstring), hip/groin strains and other conditions[28-29].
Core stability is defined as the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated athletic activities[30-31]. Core strength is thought to have a significant effect on an athlete's ability to create and transfer forces to the limbs[32].
During the season prior to that analyzed in this study, muscle injuries (n=27) accounted for 58.7% of the total: 13 of which occurred during practice and 14 during matches. The incidence of muscle injuries was 5.6 injuries/1000 hours exposure and the burden was 106.4 days absence/1000 hours exposure.
The purpose of this study was to determine the effectiveness of a prevention program in reducing muscle injuries and re-injuries in an Italian major league soccer team for which the first author was the head team physician during the 2010-2011 season.

Materials and Methods

During the 2010-2011 season, the players participated a two-tiered injury prevention program: the first level included a series of group exercises that focused on core stability; the second level comprised functional assessment for programming specific exercises that addressed the deficits found in each athlete. Our hypothesis was that when integrated in the warm-up of practice sessions, this program would have a preventive effect on muscle injury and re-injury occurrence.

Injury prevention program

Group prevention
This part of the prevention program focused on a series of core stability exercises[30] performed by the entire team before each practice session. The exercises were performed with the team in a circle, outdoors or otherwise indoors in the gym. The exercises were led by 3 physiotherapists at the center of the circle and around it, who demonstrated the correct execution of an exercise and helped the players to perfect their movements.
The exercises were:

1) dynamic stretching of hamstrings with elastic tubing: 5 repetitions for 20 sec for each side;
2) prone abdominal body bridge (body supported by elbows and toes while keeping the trunk level to the ground): 4 repetitions of 20 sec each;
3) supine extension bridge (raise the pelvis while keeping the head, back, arms and legs flat to the ground and the knees bent): 4 repetitions of 20 sec each;
4) side bridge (body supported by the elbow and the external side of the foot, return to the start position): 4 repetitions of 20 sec for each side;
5) single stand windmill touches (touch the ground with the right then the left hand): 4 repetitions of 20 sec for each side;
6) foot-catch exercise (standing on one foot, flex the contralateral hip and slowly extend the knee. remaining in balance for 20 sec): 10 repetitions for each leg;
7) push up with trunk rotation (from the push-up position, take one hand off the floor and raise it vertically as far as you can before losing control. Allow your feet and legs to rotate with your arm. Raise the arm over a period of 3 sec, hold it there for 1 sec, and lower it over 3 sec. Then repeat): 15 repetitions for each side;
8) single stand (with two players giving one hand and trying to imbalance each other): 3 repetitions of 20 sec for each side;
9) hip flexion with knee extension stretch (slowly bend the trunk forward, turn the hips to the right and then to the left, gradually bending the trunk without causing discomfort to the flexors): 4 repetitions of 20 sec;
10) nordic hamstring: in pairs, 2 sets of 5 repetitions.

After each exercise session, the team performed an additional series of running warm-up exercises.

Individual injury prevention
This part of the injury prevention program was begun after assessment with kinesiologic and diagnostic tests. At the beginning of the season, each athlete underwent testing of leg flexibility (Ober test, Thomas test, straight-leg-raising [SLR] test)[33-35]. The prone instability test[36] was carried out to reveal spinal instability and the stork test[37,38] to evaluate sacroiliac dysfunction. Quadriceps and hamstring strength were measured isokinetically[39-41]. Particular attention was directed at evaluation of manual resistance of the

force of the gluteus medius[42].
Assessment also included history taking of previous acute or overload injuries.
The athletes were allowed to work at their own pace, or assisted by a physiotherapist as needed, 2 to 3 times a week, generally after daily technical group training. Concentric isokinetic tests were performed at the beginning and at half season.
During the 2010-2011 season, athletes were offered cryotherapy with cold-water immersion (7°C for 10 min). Taking an ice bath was encouraged particularly to alleviate muscle soreness and fatigue after engaging in eccentric hamstring exercises.

Study procedure

The types of muscle injuries in players (n=36) on an Italian major league soccer team that occurred during the 2010-2011 season when the first author was the team physician are discussed below. The medical staff diagnosed the injuries that occurred during the study period. Diagnosis was based on clinical and imaging findings obtained with a magnetic resonance imaging (MRI) machine (1.5 tesla). An injury was defined as such if it occurred during a scheduled training session or match, causing the player to miss the next training session or match [43].
Muscle injuries were classified according to:

1. the number of days absent from training sessions and matches in relation to five severity categories: slight (0 days), minimal (1-3 days), mild (4-7 days), moderate (8-28 days) and severe (>28 days), including the day of injury. The number of days absent was calculated according to the calendar. An injured player was defined injured until the club medical staff cleared him for participation in full training or match play. A player who performed alternative training or participated in only a part of the training session was considered injured[44];
2. a scheme devised by Muller-Wohlfarth derived from a recent consensus statement on sports injuries in relation to indirect mechanisms of injury[45];
3. re-injuries were defined as those that occurred at the same site and early re-injuries as those that occurred at the same site no more than 3 months after the player had returned to full participation[46].

Data were recorded according to UEFA manual instructions (Italian version) which provide details on definitions and procedures for recording injuries. The medical staff kept attendance records for all training sessions and matches on a standardized UEFA form. Injuries were treated according to criteria described elsewhere[47,48].

Results

The data refer to the period between July 2010 and May 2011. The team had 8041 hours of total exposure, with 7165 (89%) training hours and 876 (11%) match hours; the training/match ratio for the season was 3.8. A total of 64 injuries occurred, 36 (56%) of which during practice and 28 (44%) during matches. Muscle injuries accounted for 31.3% of the total (n=20), 70% (n=14) of which occurred during practice and 30% (n=6) during matches.
Muscle injuries involved the biceps femoris (n=8), the semimembranosus (n=3), the rectus femoris (n=2), the adductor longus (n=2), the adductor brevis (n=1), the gastrocnemius (n=2), the psoas (n=1), and the flexor hallucis longus (n=1). Fifteen injuries occurred during running/sprinting, 2 after jumping/landing, 1 on falling/diving, and 1 during stretching; 19 were non-contact and 1 was a contact player injury. In all, 3 re-injuries occurred (15% of muscle injuries), 2 involving the semimembranosus and 1 the femoral biceps. No early re-injuries occurred. Most of the injuries occurred in August (n=5) and January (n=6), followed by 1 in July, 2 in October, 3 in November, and 1 each in February, March, and April. The incidence was 2.5 injuries/1000 hours and the burden was 37 days absence/1000 hours. Table 1 reports the severity of muscle injury in relation to absence from training and matches. Table 2 reports the number and percentage of muscle injuries classified according the Munich Consensus Statement.

Discussion

This study demonstrated the effectiveness of a personalized injury prevention program in reducing the total number of muscle injuries and days absent because of injury, in a team of elite soccer players, as compared to the previous season.
Muscles injuries represented over half of injuries during the season prior to that analyzed in this study. The

Table 1. Muscle injury severity in relation to absence from training sessions and matches.

Degree of severity	*n° of injuries*	*%*
Slight (0 days)	0	0
Minimal (1-3 days)	1	5
Mild (4-7 days)	2	10
Moderate (8-28 days)	15	75
Severe (>28 days)	2	10

Table 2. Muscle injury classification according to the Munich consensus statement.

Type of injury	*n° of injuries*	*%*
Muscle-related neuromuscular muscle disorder	13	65
Minor partial muscle tear	5	25
Moderate partial muscle tear	2	10

data from the past season are available for the period between August 2009 and March 2010. Because the medical care of the team was managed by another medical staff, the data for April and May 2010 are missing. Between August 2009 and March 2010, the team had 4848 hours of total exposure, of which 4146 (86%) were training hours and 702 (14%) match hours; the training/match ratio during the season was 3.9. In all, 46 injuries occurred, 21 (46%) of which during practice and 25 (54%) during matches.

Muscle injuries (n=27) accounted for 58.7% of the total: 13 of which occurred during practice and 14 during matches. The muscles most often involved were the hamstring (n=11), the quadriceps (n=6), the adductors (n=6), and the calf muscles (n=4). The principal mechanisms of injury were running/sprinting (n=16) and shooting (n=5). Five re-injuries occurred, accounting for 18.5% of the total muscle injuries. The incidence of muscle injuries was 5.6 injuries/1000 hours exposure and the burden was 106.4 days absence/1000 hours exposure. Injuries most often occurred in January (n=6), February (n=6), and March (n=7).

Because of the high injury rate noted for the 2009-2010 season, the club management asked us to place particular attention on reducing the negative impact injuries were having on global team performance. The prevention program described here and carried out in the 2010-2011 season reduced by half the relative distribution and the incidence of muscle injuries and reduced the muscle injury burden (Tab. 3).

When we started our experience at the club we did not find evidence of any preventive program, neither collective nor individual, concerning the 2009-2010 season.

Table 4 compares our data with those obtained by Ekstrand from a population of 1210 players from 24 professional European teams participating in the UEFA Champions League (UCL) tournament and followed over 1 to 8 seasons between July 2001 and June 2004[4]. Ekstrand's study did not report the re-injury rate.

In our series, the distribution of injuries by muscle group is similar to that reported by Ekstrand in an epidemiological study in a large sample of international level players[4], in which the hamstring was the muscle most often injured. Volpi et al. analyzed muscle injuries collected from an Italian major league soccer team between 1995 and 2000[3] and found that the quadriceps was the muscle group most often involved followed by the hamstring. This finding contrasts with more recent observations, including those from our study and Ekstrand's, in which hamstring injuries were found to be more frequent. The high number of quadriceps injuries reported by Volpi et al. may be correlated with a training regime which at the time and in that team relied largely on aggressive quadriceps training with isotonic and isokinetic exercises, potentially leading to overloading of the anterior thigh muscles. The lower hamstring injury rate may be explained by the use of proprioceptive motor control exercises and the use of eccentric isokinetic hamstring training[3] (Tab. 5).

The efficacy of core stability exercises in the prevention of muscle injuries has been previously described[49-51] .

Van Beijsterveldt et al. investigated the effect of "The 11" injury prevention program (focused on core stability, eccentric training of thigh muscles, propriocep-

Table 3. Muscle injuries recorded during the 2009-2010 and 2010-2011 seasons.

Season	*n° of injuries*	*total of injuries %*	*n° of injuries/1000 h exposure*	*days absent/ 1000 h*	*n° of re-injuries (%)*
2009-2010	27	59	5.6	106.4	5 (18.5)
2010-2011	20	31	2.5	36	3 (15)

Table 4. Data on muscle injury reported in Ekstrand et al. as compared to data from the present study.

	Total injuries %	*n° of injuries/1000 h exposure*	*Days absent/1000 h exposure*	*Re-injury rate (%)*
Ekstrand et al.	34	2.7	43	13
Present study	31	2.5	36	15 (no early re-injuries)

Table 5. Injury rate in most commonly involved muscle groups.

	Season	*Hamstring (%)*	*Adductors (%)*	*Quadriceps (%)*	*Calf (%)*
Present study	2010-2011	55	15	10	10
Ekstrand et al. [4]	2001-2009	37	23	19	13
Volpi et al. [3]	1995-2000	28	19	32	13

tive training, dynamic stabilization and plyometrics with straight leg alignment) on injury incidence and injury severity in adult male amateur soccer players: the study showed a significant, specific reduction in knee injuries[52]. The injury prevention program is a variant on the one we implemented in an Italian major league soccer team between 1995 and 2000[3]. The group injury prevention program applied in the present study places greater emphasis on a set of core stability exercises that address dynamic trunk control to improve dynamic and static balance, neuromuscular control and flexibility and strength of the major muscle groups of the pelvic girdle[53,54]. During the season prior to the one analyzed in this study, 11 injures of the femoral biceps occurred, accounting for 41% of 27 muscle injuries. This finding is in line with published epidemiological data[4,55]. For this reason, we included the Nordic hamstring eccentric exercise which has been demonstrated effective in reducing the incidence of hamstring injuries[56,57]. Among the most often reported factors of leg muscle injury is a previous injury at the same site. Prevention of the index injury plays a critically important role in averting recurrence of injury to the same anatomic site. Engebretsen et al. conducted a study to identify intrinsic risk factors for hamstring injuries among elite male soccer players. They found a previous acute hamstring injury to be a significant risk factor for new hamstring injuries. Previously injured players had more than twice as high a risk of sustaining a new hamstring injury[17]. Hagglund et al., in a study of 26 European level soccer teams observed between 2001 and 2010, reported 2123 lower limb muscle injuries, 27% of which were re-injuries with a preceding identical injury during the study period[18]. In our study, 15% (n=3) were re-injuries with a preceding identical injury: 2 involving the semimembranosus, and 1 the biceps femuris, or only half the rate reported by Hagglund. Many factors can predispose to muscle injury, among which strength deficits or imbalances have been suggested to increase hamstring injury risk[58]. In the present study, players underwent concentric isokinetic exercise testing at 180°/sec to determine peak quadriceps and hamstring torque, deficits in peak strength or imbalances between flexors and extensors in the same limb or differences between flexors and extensors in both limbs. Subsequently, specific muscle strength training exercises were included in the personal injury prevention program to correct the deficits revealed on assessment. Eccentric isokinetic testing was not part of preseason screening because we wanted to avoid problems of muscle fatigue or injury during the tests[59]. During functional recovery of hamstring injury, we measured total maximal concentric quadriceps and hamstring muscle strength and performed eccentric isokinetic testing. We considered the functional hamstring-eccentric/quadriceps-concentric ratio of the same limb as one of the criteria for return to play after a hamstring injury[60]. We allowed the player to return to training when the ratio was between 0.8 and 1 at an angular velocity of 60°/sec, with optimal eccentric hamstring strength, and when a good eccentric side-side hamstring balance was achieved, after isotonic and isokinetic muscle strength training with concentric and eccentric exercises.

The present study has some limitations.

The first is that two different medical teams were used to record injuries in the two seasons. This could lead to a sistematic bias.

During the 2009-2010 season, a greater number of muscle strains occurred than would be expected. About this, another limitation could be that we were not able to collect informations about the type of training programs that were done; hence one could argue that it's difficult to know whether it was poor training programs or simply an unlucky season which explain the high rate of muscle strains.

However, we must report that, as above mentioned, when we started our experience at the club, we did not find evidence of any preventive program, neither collective nor individual, concerning the 2009-2010 season. This, in our opinion, could explain the higher rate of muscle injury.

In conclusion, the reduction in the number of muscle injuries and days of absence due to early re-injury recorded for the 2010-2011 season was very likely attributable to:

1. an injury prevention program that comprised core stability exercises like those in the "11 Injury Prevention Program" but different in its two-tiered structure (group and individual sessions) that allowed for intense and specific training. Some prevention programs derived from "The 11" program have proved ineffective in preventing injury because of the non specific content and ineffective intensity[52,61].
2. continuity of commitment by the players to the group and individual parts of the program.
3. eccentric hamstring training was part of the group program (2 sets of 5 repetitions weekly) and the personalized program for players with a history of hamstring injury. Furthermore, at the end of each training session players were encouraged to take an ice bath[62].

Through the implementation of a group and personalized injury prevention program, with application of strict criteria for muscle injury treatment and return to play, we were able to reduce the total number of muscle injuries and days absent because of injury, without any occurrence of re-injury in a team of elite soccer players, as compared to the previous season. Specifically, muscle injuries accounted for 31% of all injuries, as compared to 59% of all injuries sustained by the team during the previous season. The number of injuries/1000 hours of exposure was reduced by half (from 5.6 to 2.5) and the days absent/1000 hours fell from 106 to 37.

Our data show a decisive improvement over the previous season and are in line with data from a large sample of international level players. In our opinion, the results could be further improved by increasing the number of group and individual prevention training sessions. The team we followed participated in 60 official and friendly matches. And as with other top teams, the tightly scheduled international weekday and national weekend games left little time for regular practice and injury prevention sessions.

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