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Reducing hamstring strains and their recurrences in Greek elite footballers: an intervention study

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Abstract

Professional footballers sustain an increased risk of muscular injuries, with hamstring strains (HS) being the most frequent amongst them. Data from a prospective study from 2001 to 2022 in professional men footballers indicated that HS constituted 19% of all injuries, while 18% among them were recurrences. Despite advancements in understanding risk factors and injury mechanisms, there remains a significant gap in research focusing on the prevention of HS in elite footballers. This study aimed to record the HS that occurred in a football team of the Greek Super League 1 over the course of three years and investigate if a strengthening program led to a reduction of HS and their recurrences. During all three years, the whole squad performed the same warm-up. Additionally, in the second and third years a muscle strengthening program was followed by players with muscular imbalances, which included isokinetic, concentric and eccentric exercises. According to our results, 36 muscle strains occurred with the majority affecting the hamstrings. The chi square test of independence showed that during the first year there was not a statistically significant difference between footballers who sustained a HS and those who did not, while in the second and third year, uninjured athletes significantly outnumbered those with HS. Recurrences also significantly declined during the last two years. These findings highlight the importance of HS prevention, as warm-ups alone were insufficient, while a strengthening program for players with muscular imbalances effectively reduced both HS occurrences and recurrences, reshaping the team's injury profile.

Keywords: hamstring strains; soccer; professional footballers; injuries; prevention; strengthening

Introduction

Professional footballers sustain an increased risk of muscular injuries, with hamstring strains (HS) being the most frequent amongst them (Biz et al., 2021; Elerian, El-Sayyad, & Dorgham, 2019). Data from a 21-year prospective study from 2001 to 2022 in professional men footballers in Europe indicated that HS constitute 19% of all reported injuries, 18% among them are recurrences, while about eight hamstring injuries per season can be expected in a squad with 25 players (Ekstrand et al., 2023).

The hamstrings consist of the biceps femoris (long and short head), the semitendinosus and the semimembranosus (from lateral to medial), cross two joints, i.e. the hip and the knee, and are both hip extensors and knee flexors (Biz et al., 2021) (except for the short head of biceps femoris which does not cross the hip joint and act only as knee flexor). HS are mainly non-contact injuries (Elerian et al., 2019) and most of them

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involve the long head of the biceps femoris (Medeiros et al., 2020). Reduced muscle strength, side-to-side imbalances (i.e. between the two limbs) and imbalances in the hamstring-to-quadriceps strength ratio have been identified as intrinsic factors for HS (Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008). Also, such injuries are often associated with the muscular demands for stretching (e.g. when performing high kicks) (Kamandulis et al., 2023) or eccentric overload in certain soccer activities (Biz et al., 2021). A critical moment of vulnerability is the late swing phase of sprinting, where the hamstrings are simultaneously lengthening and contracting eccentrically to control the forward motion of the leg: as the hip moves into flexion and the knee extends, the hamstrings undergo significant stretch since both of these movements increase stretch of this muscle group (Chumanov, Heiderscheit, & Thelen, 2011). At the same time and while being lengthened, they are required to contract forcefully (eccentric contraction) to control and decelerate the flexing hip and extending knee (Arnason et al., 2008; Medeiros et al., 2020). This places them under high mechanical stress, increasing the risk of strain. Another common point of injury is early stance/foot strike, where hamstrings transition from eccentric to concentric action (Arnason et al., 2008) to stabilize the knee and prevent excessive extension (Biz et al., 2021). Indeed, running/sprinting is the most common mechanism of HS in professional football (Ekstrand et al., 2023), while other usual mechanisms include activities such as jumping, cutting (Izzo, Giovanelli, & D' Isanto, 2019), and shooting (Suarez-Arrones et al., 2021).

A worrying trend is the rise in HS in men's professional soccer in Europe, increasing from 12% of all injuries in 2000/01 to 24% in 2021/22 (Ekstrand et al., 2023). Despite advancements in understanding risk factors, injury mechanisms and prevention strategies, there remains a significant gap in research focusing on their prevention and comparative interventions among professional footballers (Biz et al., 2021). Although numerous studies have examined injury prevention in collegiate, high-school aged, semi-professional, veteran, amateur and women footballers (Rosado-Portillo, Chamorro-Moriana, Gonzalez-Medina, & Perez-Cabezas, 2021; van de Hoef et al., 2021), professional men's football presents unique demands that require separate evaluation (McCall et al., 2020). Preventative programs for this population must account for the intense training loads and challenges of elite competition (Kamandulis et al., 2023). However, recent meta-analyses often mix diverse athletic populations – including different genders, ages, skill levels, and even sports – (Biz et al., 2021; Rosado-Portillo et al., 2021) likely due to the limited number of studies focusing exclusively on professional players. As a result, findings from such research may not be directly applicable to this specific group, highlighting the need for more targeted investigation (McCall et al., 2020).

In the few studies that have been found in elite footballers, there are inconsistent results: the effectiveness of both single-component and multi-component programs has been mixed, with some yielding positive results while others showing no significant impact. When applied to the whole squad, a protocol of isotonic contractions of the hamstrings (concentric and eccentric) led to a significant reduction of HS (Askling, Karlsson, & Thorstensson, 2003). On the contrary, a high- velocity elastic-band training for the hamstrings did not lead to a significant decrease of such injuries (Kamandulis et al., 2023). The Nordic Hamstring Exercise (NHE) alone, in some studies did not lead to a reduction of HS (Cadu, Goreau, & Lacourpaille, 2022), while in others was effective in doing so when was the only exercise performed (Elerian et al., 2019) or in combination with warm-up contract-relax stretching of the hamstrings (Arnason et al., 2008). A specialized hamstring conditioning program which was implemented only to players with muscular imbalances and incorporated isokinetic, isotonic, and manual strengthening was very effective in reducing HS (Croisier et al., 2008). As for multi-component programs which were applied

to the whole team and also included individualized training for athletes with deficits, other times they reduced the number of HS (Suarez-Arrones et al., 2021) and other times did not (Edouard et al., 2024; Melegati et al., 2013). However, in interventions that were multifaceted and complex, it was impossible to isolate the specific impact of each individual component of the training on the reduced injury rates (Suarez-Arrones et al., 2021).

These findings clearly highlight the importance of conducting assessments in professional soccer teams and implementing targeted strengthening programs for players with muscular imbalances (Croisier et al., 2008). Therefore, this study aimed to record the HS that occurred in a professional football team over the course of three years and investigate if a strengthening program implemented from the second year onwards to players with muscular deficits led to a reduction of HS and their recurrences in the team.

Materials and Methods

Participants

The study had a duration of three years and involved professional adult players of one team of the Greek Super League 1 of a mean age of 26.12 ± 5.80 years. The data derive from the Greek dissertation of the first author, which explored various aspects of football injuries and have been examined in light of contemporary knowledge, previous research, and current trends in the field. Goalkeepers were excluded from the analyses as well as players with knee instability. All participants provided informed consent. The distribution of the players of the team per year as well as their BMI are displayed in Table 1.

Table 1. Distribution and BMI of the players per year

Year	First Year	Second Year	Third Year
Players (n)	34	34	32
BMI	23.77 ± 3.00	22.92 ± 2.32	22.82 ± 2.08

Procedures

During all years, all players performed the same warm-up, supervised by the same athletic trainer. The warm up remained unchanged in the preparation and the competitive seasons. As suggested by Ekstrand, Gillquist, and Liljedahl (1983), it consisted of the “square” exercise for 10 min (i.e. four to six players form a square and pass the ball to each other, while one or two other athletes in the middle try to stop the ball) and of contract-relax stretching for the muscles of the lower limbs for 10 min (i.e. quadriceps, iliopsoas, hamstrings, adductors, and triceps surae). It was not allowed to shoot the ball before the completion of the warm-up. In the first year, the footballers only followed the regular training of the team with no extra intervention. From the second year onwards, players who presented muscular imbalances > 10% between the flexors and extensors of the knee followed a strengthening program. To locate players with muscular imbalances, isokinetic assessments were performed with a Norm, Cybex isokinetic dynamometer (knee extension and flexion at angular velocities of 60 and 180 degrees per second with concentric muscle activation). The measurements were performed at the start of the preparation season. Players who entered the team later (during the January transfer window) were also evaluated. In case a player was injured, they participated at the measurements after their recovery.

Measurements

Record of injuries

All data regarding muscle strains, their location, their severity, their recurrences, and their distribution per year were recorded by the doctor, the physiotherapist and the rehabilitation coach of the team. Based on the days a player was not capable of fully participate either in training or competition, injuries' severity was categorized as follows: 0-1 day of absence was not considered an injury; 2–6 days of absence: mild severity; 7-28 days: moderate severity; >28 days: serious severity. This classification closely aligns with the International Olympic Committee Consensus, which, however, defines mild injuries as those resulting in 2-7 days of absence (Bahr et al., 2020; Tondelli, Boerio, Andreu, & Antinori, 2021).

Strengthening Protocol

The strengthening program was performed 2-3 times per week. It focused at knee flexors and extensors and included: a) Isokinetic strength training (concentric) consisting of 10 sets of 15 repetitions of knee flexion and extension. The angular velocity started from 150 degrees/second in the first set and in every subsequent set there was an increase of 10 degrees/second, reaching at 240 degrees/second in the last (10^{th}) set; b) Isotonic exercises, performed on resistance machines, i.e. Leg Press (placing also emphasis in the eccentric phase of the exercise), Leg Extension, and Hamstring Curls (2-3 sets of 10-12 repetitions at 70% of 1 Repetition Maximum); c) Eccentric exercise, i.e. Nordic Hamstring with resistance from a co-trainer or the coach (3 sets of 6-8 repetitions).

Analyses

Analysis of the data was conducted with SPSS. Injury occurrences are given in numbers and/or percentages. The chi square (χ^2) test of independence was used to examine if: a) HS were statistically significantly more than all other muscle strains, b) there was an association between year (first, second, third) and number of HS (injured versus non-injured athletes), c) if there was an association between year (first versus second and third) and recurrence of HS (yes versus no). For point c, the second and third year were combined due to the small number of observations, and for this same reason a Likelihood Ratio Chi-Square test was also conducted.

Results

In total, 36 muscle strains occurred over the course of three years and the majority of them (83.33%) at the hamstrings. The location of muscle strains per year is displayed in Table 2.

Table 2. Location of muscle strains per year

Year	Hamstrings	Quadriceps	Gastrocnemius	Adductors
First year	14	1	2	1
Second year	9	1	0	0
Third year	7	1	0	0
Total	30	3	2	1

In only one case the muscle strain was severe. The severity of all muscle strains per year is shown in Table 3.

Table 3. Severity of muscle strains per year

Year	Severity		
	Mild	Moderate	Severe
First year	15	2	1
Second year	7	3	0
Third year	1	7	0

For the whole three-year period, HS were statistically significantly more than the sum of all other muscle strains (χ^2=16.000, df 1, p < 0.001). According to the chi square test of independence, the first year there was not a statistically significant difference between athletes who sustained a HS and those who did not (χ^2=1.059, df 1, p = 0.303). Uninjured athletes were significantly more than athletes with HS in the second (χ^2=7.529, df 1, p = 0.006) and third year (χ^2=10.125, df 1, p = 0.001). Specifically, in the first year, 41.17% of the players sustained a HS, as opposed to only 26.47% in the second and 21.87% in the third year. Compared to the non-intervention first year, the strengthening program led to a reduction of HS of 35.71% in the second year, and 50% in the third year.

In 16.66% of the cases, there was a recurrence of the strain (n=6). All recurrences occurred in the hamstrings and were five in the first year, zero in the second and one in the third year. A significant association was found between year and injury recurrence (χ^2 = 4.051, df 1, n=30, p = 0.044), as the number of recurrences differed significantly between the first year versus the second and third years, with the Likelihood Ratio Chi-Square confirming this association (χ^2 = 4.294, df 1, n=30, p = .038).

Discussion

According to the results of this study, HS were the most prominent muscle injuries in professional Greek footballers. In the first non-intervention year of the research, there was an equal possibility to sustain or not sustain a HS, since something less than half of the players presented with this type of injury. On the contrary, the next two years, and after implementing the strengthening program, this situation was reversed, while injury recurrence was nearly eliminated with only one recurrence noted in the third year. These results indicate that the prevention of HS should receive a high priority, that the specific warm-up alone was not enough to prevent such injuries, and that a strengthening program for players that presented muscular imbalances changed the injury profile of the whole team by reducing the absolute number of HS.

Our results are in accordance with the study of Elerian et al. (2019), in which a similar design was used (i.e. control period in the previous season with a 20-min “Brazilian” warm up and intervention period). Their intervention consisted of performing the NHE for 12 weeks, twice per week. They found that warm up alone was ineffective of preventing HS (13 out of 35 players sustained an injury) or their recurrences (7 out of 35 players had a recurrent HS). However, players that performed the NHE either only before training (17 players) or both before and after training (17 players) reported respectively three initial injuries and one recurrence versus one initial injury and zero recurrences. Similarly, in the study by Arnason et al. (2008) it was shown that incorporating a contract-relax hamstring stretch (3 × 20 sec per limb) during warm-up and post-training was insufficient in reducing HS in professional footballers from Icelandic and Norwegian teams. In contrast, the NHE combined with either warm-up stretching alone or both warm-up and post-training stretching, effectively reduced HS. However, no statistically significant differences were observed in recurrence rates, which remained high – 54% at baseline and 34% during the

intervention periods. Cadu et al. (2022) reported a nonsignificant 2.7-fold lower risk of HS in 23 professional players from a first division French soccer club who performed three maximal repetitions of the NHE once a week for 21 weeks compared to 23 players from the previous control season. It was noted that five injuries occurred in the experimental group and nine in the control group.

From these comparisons, it seems that NHE may or may not be effective in reducing HS and their recurrences. Therefore, although NHE is often proposed as a very effective exercise, it could be postulated that this exercise alone is not necessarily enough and should be combined with other exercises. Maybe the fact that our protocol was not exclusively based on NHE but also included isokinetic and concentric exercises offered a more holistic protection for the players, since not only the initial injury profile of the whole team changed (from injury-prone to not injury-prone) but also the recurrences in the second year completely eliminated. The value of isotonic exercises is also shown in the research of Askling et al. (2003): In a 10-month study involving elite footballers from Swedish premiere league division teams, researchers evaluated the effects of a single exercise using a YoYo flywheel ergometer. Their athletes performed 4 sets of 8 repetitions, engaging in a concentric hamstring action for knee flexion followed by an eccentric hamstring action for knee extension, from a prone position. This intervention was highly effective since the training group sustained only three injuries out of 15 players as opposed to the control group (who did not perform the exercise) with ten injuries for 15 players. On the contrary, high- velocity elastic-band training for the hamstrings from a prone position did not lead to a significant decrease of HS in Lithuanian footballers when comparing an intervention with a control group, although a reduction of HS was observed (Kamandulis et al., 2023). This finding indicates that this single exercise may be helpful but is not enough to decrease the number of HS. On the other hand, the value of a comprehensive program of concentric exercises was shown in the study of Croisier et al. (2008) that included professional players from Belgian, Brazilian and French squads. Similarly to us, they applied a specialized hamstring conditioning program, incorporating isokinetic, isotonic, and manual strengthening for players with muscular deficits. In their study, 35 out of 462 players sustained a HS and among these injuries only 10 occurred in 246 players with a normal isokinetic profile (no strength imbalances), 15 in 91 players with untreated strength imbalances, and 4 in 70 players with strength imbalances that received compensating training till the normalization of their muscular deficits. Considering that also in the present study the strengthening program led to a significant reduction of HS, we conquer with Croisier et al. (2008) that these findings clearly highlight the importance of conducting preseason isokinetic assessments in professional soccer teams and implementing targeted strengthening programs for players with muscular imbalances. However, we did not include measurements of eccentric strength in order to avoid injury and problems of muscular fatigue (Melegati et al., 2013), so, although we speculate that eccentric strength improved, we cannot be sure if this was the case.

The significance of this research lies to the fact that it was possible to monitor a team for three years in a controlled environment and focus on one modality, i.e. strength training. According to our knowledge and after extensive literature review only few preventative interventions have been conducted in elite players and most of them are mentioned in the present study. Comparing our results with those of other researchers, we conclude that it is very important to assess players for muscular deficits and that a comprehensive protocol of isokinetic, concentric and eccentric exercises seems to be effective in the reduction of HS.

Conclusions

HS were the most prominent muscle injuries in professional Greek footballers of one elite team. In the first non-intervention year of the research, there was an equal possibility to sustain or not sustain a HS, since something less than half of the players presented with this type of injury. On the contrary, the next two years, and after implementing the strengthening program, this situation was reversed, while injury recurrence was nearly eliminated with only one recurrence noted in the third year. These findings highlight the importance of HS prevention, as warm-ups alone were insufficient, while a strengthening program for players with muscular imbalances effectively reduced both HS and their recurrences, reshaping the team's injury profile.

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