Validity of an On-Field Readaptation Program Following a Hamstring Injury in Professional Soccer

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Context: Despite the presence of various injury prevention programs, the rate of hamstring injuries and reinjuries is increasing in soccer, warranting the need for a soccer-specific rehabilitation program. **Objective:** To develop and validate a new, functional on-field program for the rehabilitation and readaptation of soccer players after a hamstring strain injury through a panel of experts; and determine the usefulness of the program through its application in professional soccer players. **Design:** A 13-item program was developed, which was validated by a panel of experts and later applied to professional soccer players. **Setting:** Soccer training ground. **Participants:** Fifteen strength and conditioning and rehabilitation fitness coaches with a professional experience of 15.40 (1.57) years in elite clubs and national teams in Europe validated the program. The program was later applied to 19 professional soccer players of the Spanish First Division (La Liga). **Interventions:** Once a player sustained a clinically diagnosed injury, the player would first be subject to mobilization and strengthening exercises in the gym after undergoing treatment by percutaneous needle electrolysis. The player would then complete an on-field readaptation program consisting of 13 drills arranged in a progressive manner in terms of complexity. The drills integrated various aspects of repeated sprint abilities, retraining and reeducation of biomechanical patterns, and neuromuscular control of the core and lower limbs. **Main Outcome Measures:** Aiken's V for each item of the program and number of days taken by the players to return to play. **Results:** The experts evaluated all items of the program very highly, as seen from Aiken's V values between 0.78 and 0.98 (0.63–0.99) for all drills, while the return to play was in 22.42 (2.32) days. **Conclusion:** This program has the potential to help a player suffering from a hamstring strain injury to adapt to real-match conditions in the readaptation phase through the application of sports-specific drills that were very similar to the different injury mechanisms.

Keywords: return to play, injury management, functional rehabilitation, structured exercise intervention, repeated sprint abilities, neuromuscular training

Soccer is a sport prone to injuries with a greater number of injuries occurring during competition (41.33 lesions per 1000 h) than in training (6.02 lesions per 1000 h).¹ Muscle injuries account for about a third of all injuries in professional soccer,² and injuries to the hamstring muscle complex contributed to 37% of all noncontact injuries, with a recurrence rate between 13% and 17%.³ On an average, when a player suffers a hamstring strain injury, he/she missed 18 days and 3 to 3.5 matches,⁴ with the number of days of layoff increasing based on injury severity.⁵

Sprinting and kicking are among the principal causes of sustaining a hamstring injury in professional soccer.^{4,6} Previous research suggests that there is an association between an increased risk of injury or reinjury and hip and knee biomechanical anomalies during maximal or submaximal sprinting,⁷ or during phases of the kick when the hamstring muscles are most active.⁸ Comparing the hamstrings muscles individually, the long head of the biceps femoris experiences the greatest musculotendinous strain with respect to its length,⁹ thus presenting the highest risk of muscle injury.¹⁰

As a consequence of the high incidence, there have been many validated posthamstring strain injury rehabilitation models

proposed in the literature, principally based on evaluations and preventive and performance models in the clinical and analytical field. These include the Askling L-protocol,¹¹ the active knee extension test,¹² the active straight leg raise test,¹³ prone hip extension test,¹⁴ or the Nordic hamstring protocol.^{15,16} Other programs at a more functional level include foot catches,¹⁷ the single-leg bridge test,¹⁸ or those that include aspects of force at a neuromuscular level.^{19,20} There are programs that evaluate previously injured athletes on tests based on change of direction and sprinting, such as the 505 agility test or the T test, although they do not specifically mention a previous hamstring strain injury,²¹ despite a majority of these injuries occurring during maximal or submaximal sprinting.²²

Epidemiological research shows an increase in hamstring strain injuries by 4% every year in elite male soccer teams in Europe.³ The exact cause for this is not clear. This could be due to a variety of factors. There have been changes in the demands of the game, with greater loads in recent years, for example, there were 25.27 (7.3) sprints per match registered in the 2013–2014 Spanish La Liga season,²³ compared with 17.3 (7.7) sprints per match registered in the 2002–2004 seasons.²⁴ Another possible cause cited in the literature is incomplete rehabilitation by forcing an early return to play.²⁵ This implies that although the previously mentioned protocols, programs, and exercises have shown to be effective with the general athletic population, there appears to be a need for a soccer-specific rehabilitation program.

Such a program must have loads and movement profiles that represent match demands, which enable the player to not only recover from the injury at the earliest, but also return to play at the highest

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possible performance levels. Such a program must have a combination of indoor and on-field drills and involve functional tests that evaluate on-field performance parameters in relation to recovery.^{20,26} It ideally should be validated by a panel of experts in the field of strength and conditioning and rehabilitation in soccer to justify its practical use in a sport-specific context. Hence, the objective was to develop and validate a new, functional on-field program for the rehabilitation and readaptation of players after a hamstring strain injury through a panel of experts; and determine the usefulness of this program through its application in professional soccer players.

Methods

Study Design

A prospective, longitudinal rehabilitation and readaptation program following a hamstring strain injury consisting of 13 items was designed. This program was validated by a panel of experts, and then applied to 19 male soccer players to determine the time taken to return to play.

Participants

Fifteen strength and conditioning and rehabilitation fitness coaches (age: 37.40 [2.70] y) participated as experts in the validation study. They had a professional experience of 15.40 (1.57) years in elite clubs and national teams in England, France, Russia, and Spain (Table 1).

The players ($n = 19$, age = 24.23 [5.36] y; height = 179.87 [7.21] cm; mass = 74.78 [4.09] kg) volunteered to participate in the study and the rehabilitation program was explained to them and the staff of the clubs they belonged to. The inclusion criteria were (1) belonging to a professional soccer club in the first division between 2015 and 2018 and (2) having suffered a medically diagnosed grade II hamstring strain injury (using ultrasound and magnetic resonance imaging).²⁷ The exclusion criteria were the player suffered an illness that implied an alteration in the rehabilitation. The nationalities of players were Spain ($n = 12$), Germany ($n = 1$), Serbia ($n = 1$), Brazil ($n = 1$), Uruguay ($n = 2$), Colombia ($n = 1$), and Argentina ($n = 1$).

Procedure

The experts were sent the following program to assess:

A previously uninjured soccer player having suffered a grade II, noncontact injury to the intramuscular myotendinous junction proximal of biceps femoris would be subjected to the rehabilitation and readaptation program. This injury is the most common type of a hamstring strain injury.²⁸ The injury would have to be clinically diagnosed and confirmed by magnetic resonance imaging and/or musculoskeletal ultrasound, and initially treated with percutaneous needle electrolysis therapy²⁹ on the second day following the injury. Before subjecting the player to the on-field program (day 8, postinjury), the player would have to undergo sessions in the gym focusing on achieving a full range of motion in the hip

Table 1 Profile of the Panel of Experts Consisting of Strength and Conditioning Coaches and Rehabilitation Fitness Coaches

Highest academic qualifications		
Degree	Number	%
PhD	8	53.33
Masters	4	26.66
Graduate (sports science)	3	20
Other complementary academic qualifications		
Physiotherapist (graduate)	4	26.6
Master's in rehabilitation + physiotherapy	3	20
Master's in personal training + Master's in rehabilitation	6	40
No complementary qualifications	2	13.33
Soccer-specific coaching licenses		
Union of European Football Associations (UEFA) Pro	3	20
UEFA A	4	26.66
UEFA B	3	20
Without coaching license	5	33.33
Experience with injured players		
As strength and conditioning coaches > 10 seasons	2	13.33
As rehabilitation and strength and conditioning coaches for 10–15 seasons with elite athletes	3	20
As rehabilitation and strength and conditioning coaches > 15 seasons with elite athletes	10	66.66
Cumulative experience in career (titles)		
Championship	Seasons	Titles
UEFA Champions League	3	2
UEFA Europa League	14	1
First division	211	5 leagues + 3 cups
Second division	5	

and knee,^{30–32} and performing controlled static and dynamic drills to strengthen the lower limbs (Figure 1).³⁰

The players would then perform 13 on-field items of the rehabilitation and readaptation program (Table 2) in a progressive manner, which are arranged in an increasing order of complexity. When the player completes each of the 13 items successfully, he/she would be declared to be fit to train with the group in the same conditions as his/her uninjured teammates. If the player could not complete all the items on a given day, he/she would train the uninjured zones in the rest of the training session.

Statistical Analysis

To validate the rehabilitation and readaptation program, the items (Table 2) were sent to 15 experts. The experts were asked to rate

each item on a 5-point Likert-type scale, where the lowest possible rating ($n = 1$) corresponded to very poor relevance and the highest possible rating ($n = 5$) corresponded to very high relevance. The coefficient of content validation was calculated using Aiken's V , and its 95% confidence intervals were also determined.³⁷ A minimum score of 0.75 was needed for an item to be valid.³⁷ The calculations were carried out using Microsoft Excel 2016 (Microsoft®, Redmond, WA).

Application of the Program

The rehabilitation and readaptation program was applied to 19 male professional players of the Spanish first division. The number of days between the injury and the player's return to competition was counted.

Results

All 13 items of the rehabilitation and readaptation program were determined to be valid, as the quantitative values given by the panel of 15 experts were very high, and were reflected in the values of Aiken's V (Table 3). Players who had suffered a grade 2 hamstring strain injury returned to play competitively in 22.42 (2.32) days after undergoing this program, and did not suffer a reinjury in 6 months following return to play.

Discussion

In this study, a 13-item training program for the rehabilitation and readaptation phase following an injury to the hamstring muscle complex was proposed for professional soccer players and validated by a panel of experts. This is the first program to quantify on-field rehabilitation and readaptation following an injury to the hamstring muscle group in soccer and be validated by a panel of experts in the field of strength and conditioning and rehabilitation. The high scores obtained for the values of Aiken's V for all the 13 items confirm the relevance of this program for the intended domain and the results obtained as a consequence are meaningful.³⁷

The drills incorporated progressively increasing loads that not only enabled the players to adapt to the increasing demands of present-day soccer,²³ but also protected them from a subsequent reinjury in the 6 months following return to play. In Australian Rules Football, a recent recent study has demonstrated that increasing training loads increased return to play time, and potentially protects an athlete from a subsequent reinjury.³⁸ In this study, the number of days of layoff between competitions was within the 21 to 27 days reported for a grade II hamstring strain injury.³⁸ One needs to keep in mind that the data reported here represent the return to play time, which depends largely on the league calendar and scheduling of the international breaks.

When an athlete suffers an injury, the return to play process aims to reeducate the on-field movements that the player performed efficiently previously and that have been hindered by the appearance of the injury. This has been defined as functional sports reeducation³⁹ and refers to the entire process that begins from the onset of the injury to the complete return to play. An inadequate rehabilitation may cause persistent weakness in the injured muscle, reduce extensibility of the musculotendinous unit, and cause an altered neuromuscular control resulting in adaptive changes in the biomechanics and motor patterns of sporting movements.²⁵ The 13 items, designed to be followed in a progressive manner after the

Figure 1 — The rehabilitation program to be followed by the injured players from the diagnosis of the injury until return to play.

Table 2 The 13 Items of the Rehabilitation and Readaptation and Retraining Programs

No.	Description	Total time
1	Lateral displacements, alternative single-legged dead lifts, and controlled landing drills with lowering of the centre of gravity at controlled velocities and leverages of the stretch-shortening cycle of the hamstrings. ^{19,31}	3 min
2	Coordinated soccer-specific controlled drills at the static and dynamic level: ball control, passing, dribbling, and kicking.	6 min
3	Six discontinuous aerobic running drills (under 14 km/h) and reeducation of frontal acceleration patterns (7 s of acceleration and 3 s of deceleration).	1 min
4	Three sets of soccer-specific agility and coordination drills (with and without a ball in the same action) followed by a return to the initial position walking.	1 min 10 s
5	Three sets of intermittent, adapted high-speed running drills (15 s at velocities > 14 km/h, and 10 s < 14 km/h) in aerobic and anaerobic conditions (70–90 s per set).	3 min 30 s–4 min 30 s
6	Four sets of 4 repetitive actions (without uncertainty) with change of direction and deceleration (total displacements of 8–14 m, total time < 12 s), followed by shooting at a minigoal 12 m away. Rest of 15 s between sets.	1 min 30 s
7	Three high-intensity runs with aerobic capacity at 100%–120% maximum aerobic velocity of the athlete for 80 s, followed by 40 s rest.	4 min
8	Four tractions of 20 m with sled towing (with a 10-kg disk) in the 1-2-1 sequence with 8 s of rest between sequences, ³³ with an optional kicking drill after the sets.	52 s
9	Four sets of soccer-specific actions (with and without a ball) including 8 RSA drills without uncertainty (distance > 14 m) with patterns of deceleration/stopping, change of direction, pivoting, cushioning, and repetition. ²¹ Rest of 12 s between sets.	1 min 40 s
10	One set of 6 DRSA followed by another set of 4 DRSA drills. ³⁴ Each DRSA was carried out at a 40-m + 40-m distance (8 + 8 s) at velocities ≥ 18 km/h. There was a rest of 16 s between DRSA, and 1'45" on completion of each set.	8 min 18 s
11	Three sets of soccer-specific drills, including change of direction with uncertainty, ³⁵ and RSA. Each drill had 4 subdrills, with the total time of the set varied between 22 and 25 s. Rest of 12 s between sets.	1 min 36 s
12	Physical-tactical readaptation through soccer-specific actions between 6 and 8 min, including 4 sprints (at velocities between 28 and 30 km/h) each with a duration of 8 s, replicating situations prior to injury based on player's position. ³⁶	6–8 min
13	Four drills involving actions similar to injury mechanism at high velocities without external contact. Each drill lasted a maximum of 15 s with an incomplete recovery (<30 s).	1 min 47 s

Abbreviations: DRSA, double repeated sprint ability; RSA, repeated sprint ability.

Table 3 The Item-Content Relevance Score for All the 13 Items as Per the 15 Experts, Aiken's V, and the 95% CIs of Aiken's V

Item	1	2	3	4	5	Mean	Aiken's V (95% CI)
1	1	1	2	2	9	4.13	0.78 (0.63–0.88)
2			3	2	10	4.47	0.87 (0.73–0.94)
3			1	2	12	4.73	0.93 (0.81–0.98)
4			2	2	11	4.60	0.90 (0.77–0.96)
5			2	3	10	4.53	0.88 (0.75–0.95)
6				1	14	4.93	0.98 (0.88–1)
7			1	2	12	4.73	0.93 (0.81–0.98)
8			1	2	12	4.73	0.93 (0.81–0.98)
9			1	1	13	4.80	0.95 (0.83–0.99)
10		1	1	3	10	4.47	0.87 (0.73–0.94)
11				2	13	4.87	0.97 (0.86–0.99)
12			2	2	11	4.60	0.9 (0.77–0.96)
13				2	13	4.87	0.97 (0.86–0.99)

Abbreviation: CI, confidence interval. Note: The ratings of the 15 experts varied on a scale from 1 to 5, where 1 corresponded to very poor relevance and 5 corresponded to very high relevance.

successful completion of each, included drills and actions that were very similar to the soccer-specific movements carried out during training or matches, in an environment which was familiar for the soccer player. It integrated various aspects of repeated sprint abilities, retraining and reeducation of biomechanical patterns, and neuromuscular control of the core and lower limbs.

The highest ratings (>0.9) were obtained for items 3, 6, 7, 8, 9, 11, and 13, which incorporated repeated sprint abilities⁴⁰ and a reeducation and retraining of acceleration–deceleration patterns (with repeated changes of direction)⁴¹ involving movements specific to soccer (Tables 2 and 3) and the player positions.⁴² Such actions are very common in soccer, where a player on an average performs

between 3 and 40 sprints in a competitive game.²⁴ They have increasingly formed a part of soccer training,⁴³ testing for return to play criteria postsoccer injuries,⁴⁰ and in rehabilitation in the case of a previous hamstring strain injury.⁴⁴ All of these considerations have been introduced at the aerobic and anaerobic level in the validated training presented within this program in relation to return to play.

Drills involving movements similar to the injury mechanism, focusing on agility and coordination, were incorporated throughout the 13 items. Previous research has shown that the eccentric control of the knee as the hip flexed in movements where high forces were generated was important.^{45,46} Such movements can be seen during the terminal swing while sprinting at submaximal and maximal velocities,²² or in the follow-through phase following kicking.⁸ These studies have shown that there are biomechanical differences between the previously injured and uninjured limbs in these drills. A deficiency in the previously injured limb might be one of the reasons as to why the hamstring muscle complex has a high reinjury rate. The rehabilitation program proposed the included drills that focused on the reeducation of these general and soccer-specific movement patterns with the complexity increasing successively in the items.

Neuromuscular control also formed an important part of the program. Given the dual innervation of the biceps femoris,⁴⁷ a possible asynchrony in the coordination may be the reason why the biceps femoris is the most commonly injured muscle of the hamstring muscle complex.⁵ Neuromuscular training has shown to be effective in reducing the risk of knee injuries,⁴⁸ and an adequate proximal muscle control has been shown to be important during maximal sprinting to decrease the hamstring injury risk.^{19,31} In addition, a deficit of neuromuscular control in the hamstring muscle complex has been shown to be a risk factor for an anterior cruciate ligament tear.⁴⁹ Therefore, the program combined various drills with and without uncertainty to reeducate motor patterns.

This program has a very high relevance in professional soccer as it contains 13 on-field items, the successful completion of all determining that the player is fit to return to play. These involve drills that are very similar to actions the players execute during matches and training. The drills also emphasize reeducation of the different injury mechanisms, in an environment very similar to where they occur, and as a result can go a long way in preventing a reinjury to the hamstring muscle complex. Although the program was applied to 19 professional players and no subsequent reinjuries were reported, comparing preinjury and postinjury data during matches with the help of Global Positioning System data could demonstrate the improvement in the players and how effective this program can be.

Conclusion

The program proposed for the rehabilitation and readaptation phase following an injury to the hamstring muscle complex was determined to be valid by the panel of experts, given its soccer-specific context and that the entire program was carried out on the field. This program has the potential to help an injured player adapt to real-match conditions in the rehabilitation phase by including drills that are very similar to those that the player carries out on the field, and this was evident with the practical application of the program.

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