ORIGINAL SCIENTIFIC PAPER

Reintegration Program for Professional Football Players after Grade 2 Hamstring Injuries

Georgios Bourogiannis[1], Dimitris Hatzimanouil[1], Eleni Semanltianou[1], Ioannis Georgiadis[1], Evaggelos Sykaras[1]

Affiliations: [1]Aristotle University Of Thessaloniki, Department of Physical Education & Sport Science

Correspondence: G. Bourogiannis. Aristotle University of Thessaloniki, Department of Physical Education & Sport Science, Thermi, 57001, Thessaloniki. E-mail: giwrgosbouro@gmail.com

Abstract

Hamstring strains are among the most common injuries in soccer, with an increased risk of recurrence. There are three stages in injuries: 1 Diagnosis, 2 Physiotherapy – Rehabilitation, 3 Reintegration. The present study investigated the reintegration actions (return to play – RTP) for eight professional footballers (Super League 1) after hamstring strain. Eight professional soccer players who had hamstring injuries with Grade 2 strain were measured and evaluated. Two measurements were taken before and after injury. The first measurement involved maximum effort field tests of 30, 40, 50 and 60 meters in a straight line without a ball, using global positioning system (GPS) devices placed on the athletes for the interpretation and evaluation of their results. The second measurement aimed to evaluate the maximum strength of the eight players before and after their injury, using squats, bench presses and leg curl exercises on the machine. The statistical analysis included descriptive and inductive statistics (paired t-test). Analysis of the data collected showed that all soccer players had higher performance in the measurements taken after injury, both in speed and in maximal strength. In conclusion, following the appropriate rehabilitation and reintegration, the eight athletes were not affected by their injury and managed to return to competitive action (RTP) without recurrence and maximizing their performance.

Keywords: *Reintegration, injury, hamstrings, footballer, rehabilitation*

@MJSSMontenegro
REINTEGRATION PROGRAM FOR PROFESSIONAL FOOTBALL PLAYERS
http://mjssm.me/?sekcija=article&artid=250

Cite this article: Bourogiannis, G., Hatzimanouil, D., Semanltianou, E., Georgiadis, I., & Sykaras, E. (2023) Reintegration Program for Professional Football Players after Grade 2 Hamstring Injuries. *Montenegrin Journal of Sports Science and Medicine*, 19 (1), 35–42. https://doi.org/10.26773/mjssm.230305

Introduction

Hamstring injuries are common in many sports including football (Kujala et al., 1997). Strain is the typical pattern of injury and results from excessive stretching of the muscle, often during sprinting or jumping (Slavotinek et al., 2010). More than 70% of football players injure their hamstrings during sprints (Skling et al., 2014). Failure to properly rehabilitate – reintegrate or an early return can lead to a relapse and a lost season (Mendez et al., 2022). It has been investigated that the majority of training and competitive actions in intermittent sports like football occur within 5-30m (Carling et al., 2016). They evaluated speed using a 30-meter sprint test with speed measured at 10 meters, 20 meters and 30 meters (Altmann et al., 2019). However, the speed at distances of 40, 50 and 60 meters has not been investigated. These distances 40,50,60 meters can occur in football firstly, in actions during the game by the fullbacks, who have to attack and return to their position back in defense in case the ball is lost, and secondly,

Received: 12 November 2022 | Accepted after revision: 26 February 2023 | Early access publication date: 1 March 2023 | Final publication date: 15 March 2023

Conflict of interest: None declared.

when central defenders in static situations are advanced to score and have to run quickly back into defense in case of a counter attack by the opposing team. For the above reasons our players were also subjected to the 40,50 and 60 meters speed tests. (Diagnosis, which is stage 1, is performed on players to determine the severity of the injury and make a proper evaluation. This is usually done clinically with either magnetic resonance imaging (MRI) or ultrasound. This is very important as a first step to have an accurate knowledge of the extent of the injury and the length of time the player will be absent from active play (Schneider-Kolsky et al., 2006). Furthermore, MRI offers a detailed analysis of the injury and is the preferred method for elite athletes in an attempt to prevent re-injury for those players who may return to training prematurely (Mendiguchia J et al., 2011).

The second stage, concerning physical therapies to be followed by football players, consists of proper management to relieve the pain and for the gradual healing of the torn muscle (Cohen – Bradley et al., 2007). With stage 2 the players should have fully gained full range of motion of their limb. With another diagnostic test to confirm that the muscle has healed they are ready for stage 3, rehabilitation (Askling et al., 2007). High intensity total distance and sprints are extremely important factors in the reintegration stage for returning football players to a better condition than they were before the injury (Mohr et al., 2003). Therefore, the amount of high intensity running combined with lower limb maximum strength training can be considered indicators of increased performance after a hamstring injury (Tol et al., 2014).

Therefore, with appropriate/correct rehabilitation and reintegration, professional footballers restore their high performance standards and maximize them by returning to better physical fitness than before (Sherry & Best, 2004).

About the mechanisms, hamstring injuries occur in sport activities requiring sprinting, cutting movements, acceleration efforts and extreme stretch movements (Schache et al., 2012). However, within the hamstring muscular complex it is important to split the injury mechanisms into biceps femoris (BF), semimembranosus (SM), and semitendinosus (ST) muscles lesions. The hamstring muscular complex during the running biomechanics is active from the beginning of the mid-swing phase until the terminal stance phase (Drezner et al., 2003). During this period of time, the BF is the muscle that undergoes the most elongation, equal to approximately 12% of its rest length. In the same phase, the SM is the flexor muscle producing the most important strength peak and absorbing the most important parts of the power production (Schache et al., 2012). For these reasons, the BF and SM injuries are substantially different. In other words, the BF injury mechanism is mainly based on an overstretching event, while the SM injuries are mainly based on a strength/power overproduction (Askling et al.,2007). This led to the aim of the present study, which was the investigation of the reintegration actions (return to play – RTP) through an appropriate individual program and tests, for eight professional footballers (Super League 1) after grade 2 hamstring strain.

Methods

The study sample consisted of eight professional football players (Super League 1) who had suffered a grade 2 strain in the first half of the 2020-2021 season. Three were midfielders, two were strikers, one was a winger, one was a central defender and one was a fullback. Before being injured, the players were subjected to the following tests: speed field test using GPS at 30, 40, 50 and 60 meters, and biceps unipedal flexions with maximum force of 1RM on the leg curl machine. Depending on the position they were competing in, the players had to cover specific high intensity meters in the speed field test (Bayer et al., 2018). At the beginning of stage 1 of the players' injury, the team's orthopedic doctor performed an MRI and ultrasound scans to accurately determine the extent of the injuries. They were evaluated and determined by the orthopedic doctor to be grade 2 contusions with muscle fiber tears. At the end of stage 2 and before the start of stage 3, which involves reintegration, the same diagnostic tests (MRI and ultrasound scans) were performed again to determine if there was muscle healing and if the athletes were ready to begin reintegration.

The initial tests were performed after preparation as s baseline measurement and a benchmark. The time period from injury to return to competitive action was the same for all players. You cannot know when a player will be injured. So the players had the same recovery time and were evaluated in the same time period after their injury. The results are comparable because there was no focus on the time between the initial measurement and the injury, for the reason that an injury cannot be predicted.

The eight professional football players had no previous injuries, so they were selected and not excluded from the study. 1 Midfielder: age 33, height 1.85, weight 78, BMI 22, 79. 2 Midfielder: age 29, height 1.82, weight 75, BMI 22, 64. 3 Midfielder: age 25, height 1.71, weight 65, BMI 22, 23.

4 Striker: age 21, height 1.86, weight 77, BMI 22, 26. 5 Striker: age 29, height 1.88, weight 80, BMI 22, 63. 6 Winger: age 24, height 1.79, weight 75, BMI 23, 41. 7 Central defender: age 27, height 1.93, weight 80, BMI 21, 75. 8 Fullback : age 26, height 1.74, weight 67, BMI 22, 13.

Inclusion: The football players included in the study participated in all training sessions, had playing time in official matches and had no serious injuries in the previous season. Exclusion: The football players excluded from survey did not participate in all training sessions, had no playing time in official matches and had serious injuries in the previous season.

Speed field test using GPS

For the purposes of the test, the midfielders had to cover a total distance of 600 meters at very high intensity (VHI Drills / maximal intent), 3 sets of 30 meters – 3 sets of 40 meters – 3 sets of 50 meters – 4 sets of 60 meters. There was a break of 30-40 seconds between the repeats and a 3-minute break between sets. The footballers competing in the attack had to cover a total distance of 720 meters at very high intensity (VHI Drills / maximal intent), 5 sets of 30 meters – 3 sets of 40 meters – 3 sets of 50 meters – 5 sets of 60 meters. There was a break of 30-40 seconds between the repeats and a 3-minute break between sets. The lateral striker had to cover a total distance of 720 meters at very high intensity (VHI Drills / maximal intent), 5 sets of 30 meters – 3 sets of 40 meters – 3 sets of 50 meters – 5 sets of 60 meters. There was a break of 30-40 seconds between the repeats and a 3-minute break between sets. The central defender had to cover a total distance of 540 meters at very high intensity (VHI Drills / maximal intent), 3 sets of 30 meters – 3 sets of 40 meters – 3 sets of 50 meters – 3 sets of 60 meters. There was a break of 30-40 seconds between the repeats and a 3-minute break

DOI 10.26773/mjssm.230305

between sets. The lateral defender had to cover a total distance of 720 meters at high intensity (VHI Drills / maximal intent), 5 sets of 30 meters – 3 sets of 40 meters – 3 sets of 50 meters – 5 sets of 60 meters. There was a break of 30-40 seconds between the repeats and a 3-minute break between sets.

Table 1 shows the distances (meters) covered by our football players during matches and the average high-intensity distance (speed over 18 km km/h) covered during a match at the professional level depending on the position of each player. We selected our study's speed limits according to our team's GPS data.

Table 1. High Intensity Distances (Meters) Covered by our football Players during Matches

Player position	Average – level of our professional team
Central Defenders	430 meters
Fullbacks	680 meters
Central Midfielders	580 meters
Wide Midfielders	740 meters
Attackers	620 meters
Average	630 meters

Maximum test measurement 1RM

The football players underwent the prescribed 1RM maximum force measurement for one exercise in the training program, the leg curl exercise. Prior to the 1RM test all participants followed a standard warm-up routine of one set of 10 repetitions with approximately 50% of the sub maximal loads to follow, using the correct movement technique. To determine the sub maximal force loads, a progressive increase in kilograms was performed for each exercise until the football players were unable to complete a repetition with correct technique. A 3-5 minute break was given between sets. 1RM was achieved between 4-5 attempts. All measurements were performed with a fixed body position, using the same resistance equipment, by the same trainer (Śliwowski et al., 2015).

Reintegration stage (training process)

During the 3rd stage of their injury, the reintegration stage, all eight players followed a program which lasted 11 days, and on the 12th day they started training with the rest of the team. The program, described in Table 2, represents a very high intensity progression during rehabilitation of a grade 2 hamstring strain injury, taking into account an average very high intensity game profile of 630 meters (Very High Intensity Distance).

Table 2. Reintegration Program (Ferreira et al., 2018)

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
0-10% Match Average	N/A	30% Match Average	N/A	N/A	60% Match Average	N/A	N/A	60% Match Average	N/A	N/A	
0-63m without sprint distance	N/A	190m without sprint distance	N/A	N/A	380m touching sprint distance	N/A	N/A	630m achieving maximum speed	N/A	N/A	
VHI Exploratory Technical Drills / W Length below 30m to avoid covering considerable amount of VHI distances but allowing the player to achieve it if comfortable.	OFF	VHI Drills 2x (4x30m) in 5sec. + 1x40m in 6 sec. 30sec active / passive rest between repetitions and 3 min between sets.	OFF	OFF	VHI Drills 2x(4x40m) in 6 sec. + 2x50m in 6sec + 2x40m in 5sec– achieve sprint speed. 30sec active/ passive rest between repetitions and 3 min between sets.	OFF	OFF	VHI Drills w/ maximal intent. 2x(3x50m) in 8sec + 1x50m in 7sec + 1x(4x60m) in 10sec + 1x(3x60m) in 8sec. 30-40sec active/ passive rest between repetitions and 3 min between sets.	OFF	OFF	Start Training with the team
Core Stability	Recovery Strategies Unloading Legs	Legs Maximum Strength Training 85%.	Upper-Body	Core Stability	Recovery Strategies Unloading Legs	Upper-Body	Core Stability	Legs Maximum Strength Training 85%.	Upper-Body	Core Stability	

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-Wilk normality tests were performed. There was equal distribution so a paired correlation test was performed. There was a correlation between the values. In the 1st, 3rd, 5th, 7th variable, the 30, 40, 50 and 60-meter distances, a paired t-test was used to test whether there was a difference between the maximum kilometer speed before and after the strain. In the 2nd, 4th, 6th, 8th variable, the 30, 40, 50 and 60-meter distances, a paired t-test was used to test whether there was a difference between the time before and after the strain. In the 9th variable, the 1RM maximum force test, a paired t-test was used to ascertain whether there was a difference between the maximum left hamstring strength before and after the strain. In the 10th variable, the 1RM maximum force test, a paired t-test was used to ascertain whether there was a difference between the maximum right hamstring strength before and after the strain.

Results

30 meters

The results showed a significant statistical difference between the maximum mileage for the 30-meter distance before and after the strain, t (7) = 5.694, p = .001. Pre-injury performance of the football players ranged from 19.00 to 22.00 km/h maximum speed. Post-injury with proper rehabilitation the players achieved higher values ranging from 20.00 to 23.00 km/h maximum speed. All the players had higher maximum speed (km/h) in their post-injury test of 30 meters. Figure 1 shows the difference between the maximum speed (km/h) for the 30 m distance before and after the injury.

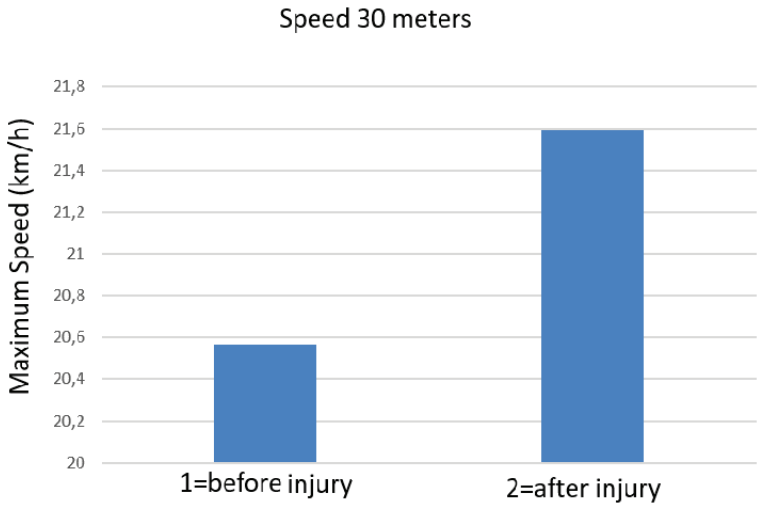

Figure 1. 30-meter distance test before and after injury.

The results showed a significant statistical difference between the times for the 30-meter distance before and after the strain, t (7) = 5.916, p = .001. Pre-injury performances of the football players ranged from 5 to 5.60 seconds. Post-injury we found that players achieved lower times ranging from 4.70 to 5.30 seconds. All the players had better times in the 30- meter run.

40 meters

The results showed a significant statistical difference between the maximum mileage for the 40-meter distance before and after the fracture, t (7) = 6.328, p = .001. Pre-injury performance of the football players ranged from 20.00 to 22.00 km/h maximum speed . Post-injury with proper rehabilitation players achieved higher values ranging from 21.00 to 27.00 km/h maximum speed. All the football players had higher maximum speed (km/h) in their post-injury test of 40 meters. Figure 2 shows the difference between the maximum speed (km/h) for the 40-meter distance before and after the injury.

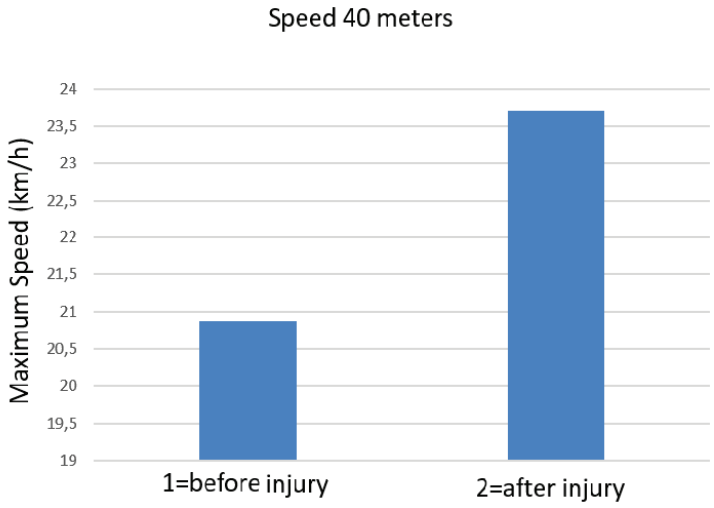

Figure 2. 40-meter distance test before and after injury.

DOI 10.26773/mjssm.230305

The results showed a significant statistical difference between the times for the 40-meter distance before and after the strain, t (7) = 8.147, p = .001. Pre-injury performance of the football players ranged from 6.60 to 7.29 seconds. Post-injury we found that players achieved lower times ranging from 5.50 to 6.75 seconds. All the players had better time in the 40-meter run.

50 meters

The results showed a significant statistical difference between the maximum mileage for the 50-meter distance before and after the strain, t (7) = 11.434, p = .001. Pre-injury performance of the football players ranged from 20.50 to 22.50 km/h maximum speed. Post-injury with proper rehabilitation players achieved higher values ranging from 23.00 to 28.00 km/h maximum speed. All the footballers had higher maximum speed (km/h) in their post-injury test of 50 meters. Figure 3 shows the difference between the maximum speed (km/h) for the 50-meter distance before and after the injury.

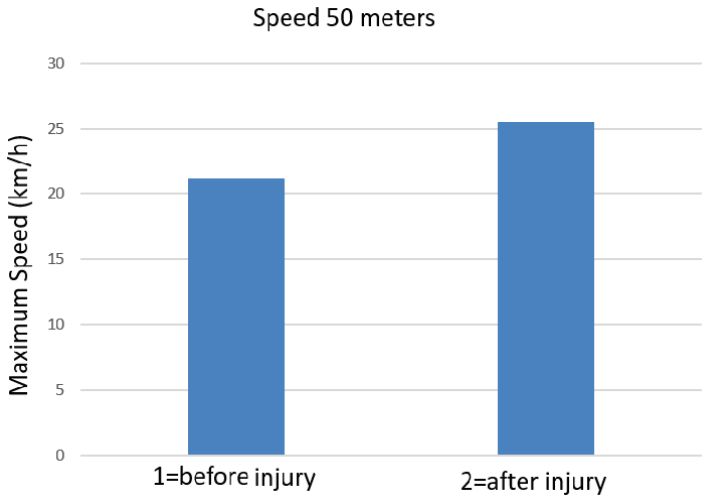

Figure 3. 50-meter distance test before and after injury.

The results showed a significant statistical difference between the times for the 50-meter distance before and after the strain, t (7) = 15.809, p = .001. Pre-injury performances of the football players ranged from 8.10 to 8.80 seconds. Post-injury we found that the players achieved lower times with values ranging from 6.50 to 7.75 seconds. All the players had better time in the 50-meter test.

60 meters

The results showed a significant statistical difference between the maximum mileage for the 60-meter distance before and after the strain, t (7) = 11.259, p = .001. Pre-injury performance of the football players ranged from 20.40 to 21.60 km/h maximum speed. Post-injury with proper rehabilitation players achieved higher values ranging from 23.00 to 28.00 km/h maximum speed. All the players had higher maximum speed (km/h) in their post-injury test of 60 meters. Figure 4 shows the difference between the maximum speed (km/h) for the 60-meter distance before and after the injury.

The results showed a significant statistical difference between the times for the 60-meter distance before and after the strain, t(7) = 16.269, p = .001. Pre-injury performance of the football players ranged from 10 to 10.60 seconds. Post-injury we found that football players achieved lower times ranging from 7.80 to 9.20 seconds. All the players had better times in the 60-meter test.

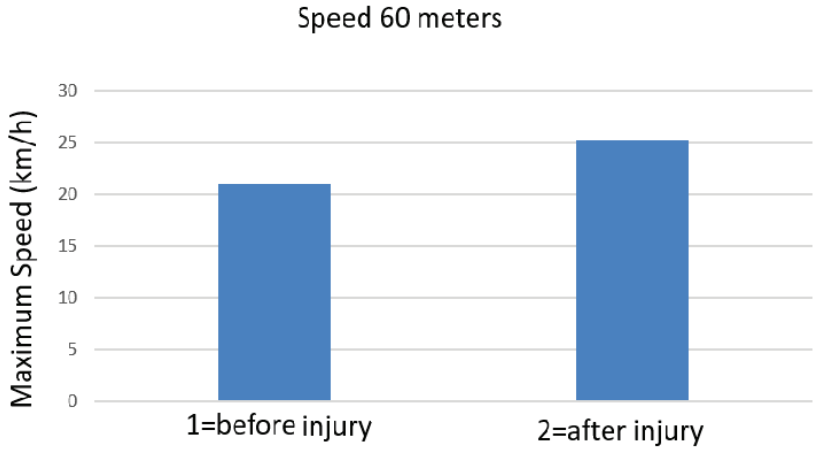

Figure 4. 60-meter distance test before and after injury.

Max Test 1RM

The results showed a significant statistical difference between maximal left hamstring strength before and after

the strain, t (7) = 4.369, p = .001. Pre-injury performance of the football players ranged from 20 to 40 kg. After injury and appropriate rehabilitation the players achieved higher values ranging from 25 to 45 kg. All of the players had greater peak strength on their tests (1RM) post-injury, so they had better results after injury.

Discussion

The eight professional football players in all variables had better results in both high intensity runs measured using GPS and maximum power. At 30 meters the footballers achieved better times and higher maximum speed (km/h) in their post-injury tests. At 40 meters the footballers also achieved better times and higher maximum speed (km/h) in their post-injury tests. In the 50-meter tests, the footballers also achieved better results in time and maximum speed after the injury than before. The same was true for the 60-meter speed tests. In the right hamstring maximum strength test all footballers had a higher maximum strength in their tests (1RM) after injury. In the left hamstring maximum strength test (1RM) the players also achieved better values after injury than before injury. So the footballers showed an improvement after the injury compared to before.

We believe that this improvement occurred due to the right, appropriate and individualized program tailored to each player's needs that they followed according to the position they played during rehabilitation. With proper rehabilitation and reintegration they recovered to a better level than they were before, improved their weaknesses and finished the season without a relapse or new injury. We believe that prior to the injury the players had deficits in the specific muscle group of the hamstrings. This was the reason they were injured and missed part of the season with a grade 2 strain. Some studies, such as (Woods et al., 2020), disagree with our results: the return of football players to competitive activity after a hamstring strain was not associated with similar high-speed running performance. The deficits observed in high-speed running may be present for many players following a hamstring strain (Orchard et al., 2005).

Brooks et al. (2006) found recurrent injuries in the same places, with recurrences at a rate of 23%. This means that something in the whole rehabilitation – reintegration process did not go as it should, leading to frequent recurrences of the hamstring injuries. According to another study (Mendiguchia 1 et al., 2014), the performance of players with a history of hamstring strain was worse after injury than before injury, with a frequent rate of recurrence. Moreover 67% of hamstring injuries in professional football show a post-injury deficit of more than 10%. So it seems that rehabilitation programs are not working properly because if they were there would be no deficit or atrophy. All the ratios would be at the percentages they should be (Tol et al., 2014).

In contrast, there were also studies that agreed with ours. They showed that the rehabilitation program they followed not only prevented injuries but also improved the players' performance at high speeds (Jiménez-Rubio et al., 2019). Another study (Skling et al., 2013) showed potential improvements compared to pre-injury performance in maximum speed, sprinting and high-intensity running. The footballers returned healthy 6 weeks after injury. Another study, however (Mendiguchia J et al., 2011), reports that the players returned neither better nor worse after the injury. According to this study, the football players returned to the exact same pre-injury performance after the rehabilitation – reintegration program.

Although the strong point of the present study is the high level of the athletes who were examined and applied the program (Super League 1 professional football players), the results must be interpreted with caution and a number of limitations should be borne in mind. The first limitation is that the sample of the present study was too small. Only eight players were subjected to the tests and followed the reintegration program. Further research is needed with a much larger sample, although this is difficult to achieve when professional players and professional teams are involved. The second limitation of the present study is the distance used to assess and evaluate the players during the reintegration program tests (average high-intensity distance of 630 m at a speed of more than 18 km/h). These distances, as Table 1 shows, were obtained according to data from tests of high-level European professional teams. However, Greece does not belong to the highest class of European professional teams. Obviously, given this limitation, there is a need for research on each individual country group in order to ensure the representativeness of the sample in the European population and make the results of the statistical analysis specific to each country group. Thirdly, it should be noted that the subjective assessment of the participants (subjective assessment of their readiness to return to the team's competitive activities), using specific self-evaluation questionnaires, was not taken into account. Thus further research is needed with this supplementary element in mind, in order to gather even more information on the players' readiness to return to the competitive activities of a team and the overall efficiency of a reintegration program. Indeed, many professional football teams consider eccentric exercises for the hamstrings the most important for preventing injuries to these muscles (Thorborg et al., 2012). In the injured players, atrophy was observed in the injured limb, once again highlighting the need to strengthen the whole body during the rehabilitation stage and also after the injury, when the players return to training with the rest of the team (Ekstrand J et al., 2015). It is also recommended to increase the number of sets on the injured limb until it is in full balance with the other limb. This is the only way to avoid recurrences or new injuries in the future (Bayer, et al., 2018).

Although there is a great deal of research on the reintegration of footballers into their previous sporting activity, very few studies concern high-level athletes or professional footballers playing in a country's top league (Brughelli et al., 2010).

Conclusions

According to our study, the eight professional football players in all variables had better results in both maximum strength tests and the different speeds they were subjected to. More specifically, in the 30,40,50,60 meters speed tests that we investigated in our team, the players improved their physical performance than before their injury according to the results. Importantly they didn't present any new injuries. We believe that this is because the rehabilitation program helped them to improve their physical condition and reach a higher level than before their injury, training globally (for all major muscle groups) and more effectively. All the players came back in the second half of the season with the right rehabilitation –

DOI 10.26773/mjssm.230305

reintegration at a better level than they had been previously, and finished the season healthy. There was no recurrence or new injury in these players for at least six months. They also played many minutes in official team games, demonstrating the effectiveness of the rehabilitation – reintegration program we implemented. Of course this particular issue needs further research, 40,50,60 meters speed tests could be researched more by other scientists, to see more results and whether they agree or disagree with our research.

References

Altmann, S., Ringhof, S., Neumann, R., Woll, A., & Rumpf, M. C. (2019). Validity and reliability of speed tests used in soccer: A systematic review. PloS one, 14(8), e0220982.

Askling, C. M., Tengvar, M., Saartok, T., & Thorstensson, A. (2007). Acute first-time hamstring strains during high-speed running: a longitudinal study including clinical and magnetic resonance imaging findings. *Clin. J. Sports Med*., *35*(2), 197-206. https://doi.org/10.1177/0363546506294679.

Bayer, M.L., Hoegberget-Kalisz, M., Jensen, M.H., Olesen, J.L., Svensson, R.B., Couppé, C., & Kjaer, M. (2018). Role of tissue perfusion, muscle strength recovery, and pain in rehabilitation after acute muscle strain injury: A randomized controlled trial comparing early and delayed rehabilitation. *Scand. J. Med. Sci. Sports*, *28*(12), 2579–2591. https://doi.org/10.1111/sms.13269.

Brooks J.H., Fuller C.W., Kemp S.P., & Reddin D.B. (2006). Incidence, risk, and prevention of hamstring muscle injuries in professional rugby union. *Am. J. Sports Med*., *34*(8),1297-1306. https://doi.org/10.1177/0363546505286022.

Brughelli M., Cronin J., Mendiguchia J., Kinsella D., & Nosaka K. (2010). Contralateral leg deficits in kinetic and kinematic variables during running in Australian rules football players with previous hamstring injuries. *J. Strength Cond. Res.*, *24*(9), 2539–2544.

Carling C, Bradley P, McCall A, Dupont G. Match-to-match variability in high-speed running activity in a professional soccer team. *J Sports Sci.* 2016 Dec;34(24):2215–23. [PubMed] [Google Scholar]

Cohen S.B., & Bradley J.P. (2007). Acute proximal hamstring rupture. *J. Am. Acad. Ortho. Surg*., *15*(6), 350-355. https://doi.org/10.5435/00124635-200706000-00004.

Drezner JA. Practical management: hamstring muscle injuries. Clin J Sport Med 2003;13(01):48–52

Ekstrand, J., Hagglund, M., & Walden, M. Epidemiology of muscle injuries in professional football (soccer) (2011). *Am. J. Sports Med.*, *39*(6), 1226–1232. https://doi.org/10.1177/0363546510395879.

Ekstrand, J., Walden, M., & Hagglund, M. (2016). Hamstring injuries have increased by 4% annually in men's professional football, since 2001: A 13-year longitudinal analysis of the UEFA Elite Club injury study. *Br. J. Sports Med*., *50*(12), 731–737. https://doi.org/10.1136/bjsports-2015-095359.

Jiménez-Rubio, S., Navandar, A., Rivilla-García, J., Paredes-Hernández, V., & Gómez-Ruano, M. Á. (2019). Improvements in match-related physical performance of professional soccer players after the application of an on-field training program for hamstring injury rehabilitation. *Journal of Sport Rehabilitation*, *29*(8), 1145-1150. https://doi.org/10.1123/jsr.2019-0033.

Kujala U.M., Orava S, & Järvinen M. (1997). Hamstring injuries: current trends in treatment and prevention. *Sports Med.*, *23*(6), 397-404. https://doi.org/10.2165/00007256-199723060-00005.

McCall, A., Carling, C., Davison, M., Nedelec, M., Le Gall, F., Berthoin, S., & Dupont, G. (2015). Injury risk factors, screening tests and preventative strategies: A systematic review of the evidence that underpins the perceptions and practices of 44 football (soccer) teams from various premier leagues. Br. *J. Sports Med., 49*(9), 583–589. https://doi.org/10.1136/bjsports-2014-094104.

Mendez-Villanueva, A., Nuñez, F. J., Lazaro-Ramirez, J. L., Rodriguez-Sanchez, P., Guitart, M., Rodas, G. Martin-Garetxana, I., Lekue, J., Di Salvo, V., & Suarez-Arrones, L. (2022). Knee flexor eccentric strength, hamstring muscle volume and sprinting in elite professional soccer players with a prior strained hamstring. *Biology*, *11*(1), 69. https://doi.org/10.3390/biology11010069.

https://doi.org/10.1519/JSC.0b013e3181b603ef.

Mendiguchia J, & Brughelli M. (2011). A return-to-sport algorithm for acute hamstring injuries. *Phys. Ther. Sport, 12*(1), 2–14. https://doi.org/10.1016/j.ptsp.2010.07.003.

Mendiguchia, J., Samozino, P., Martinez-Ruiz, E., Brughelli, M., Schmikli, S., Morin, J. B., & Mendez-Villanueva, A. (2014). Progression of mechanical properties during on-field sprint running after returning to sports from a hamstring muscle injury in soccer players. International journal of sports medicine, *35*(08), 690-695. https://doi.org/10.1055/s-0033-1363192.

Mohr M, Krustrup P, & Bangsbo J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *J. Sports Sci.,21*(7), 519-528. https://doi.org/10.1080/0264041031000071182.

Orchard J, Best T.M., & Verrall G.M. (2005). Return to play following muscle strains. *Clin. J. Sport Med*., *15*(6), 436-441. https://doi.org/10.1097/01.jsm.0000188206.54984.65.

Schache AG, Dorn TW, Blanch PD, Brown NA, Pandy MG. Mechanics of the human hamstring muscles during sprinting. Med Sci Sports Exerc 2012;44(04):647–658

Schneider-Kolsky M.E., Hoving J.L., Warren P, & Connell D.A. (2006). A comparison between clinical assessment and magnetic resonance imaging of acute hamstring injuries. *Am. J. Sports Med*., *34*(6), 1008-1015. https://doi.org/10.1177/0363546505283835.

Sherry M.A., & Best T.M. (2004). A comparison of 2 rehabilitation programs in the treatment of acute hamstring strains. *J. Orthop. Sports Phys. Ther*., *34*(3), 116-125. https://doi.org/10.2519/jospt.2004.34.3.116.

Skling C.M., Tengvar M., Tarassova O., & Thorstensson A. (2014). Acute hamstring injuries in Swedish elite sprinters and jumpers: a prospective randomised controlled clinical trial comparing two rehabilitation protocols. *Br. J. Sports Med.*, *48*(7), 532-539. https://doi.org/10.1136/bjsports-2013-093214

Slavotinek J.P. (2010). Muscle injury: the role of imaging in prognostic assignment and monitoring of muscle repair. *Semin. Musculoskelet Radiol.,14*(2), 194-200. https://doi.org/10.1055/s-0030-1253160.

Śliwowski R., Jadczak Ł., Hejna R., & Wieczorek A. (2015). The Effects of Individualized Resistance Strength Programs on Knee Muscular Imbalances in Junior Elite Soccer Players. *PLoS ONE, 10*(12), e0144021. https://doi.org/10.1371/journal. pone.0144021

Thorborg K. (2012). Why hamstring eccentrics are hamstring essentials. *Br. J. Sports Med., 46*(7), 463–465. https://doi.org/10.1136/bjsports-2011-090962.

Tol, J. L., Hamilton, B., Eirale, C., Muxart, P., Jacobsen, P., & Whiteley, R. (2014). At return to play following hamstring injury the majority of professional football players have residual isokinetic deficits. *Br. J. Sports Med., 48*(18), 1364-1369. https://doi.org/10.1136/bjsports-2013-093016.

Van Der Horst, N., Backx, F. J. G., Goedhart, E. A., & Huisstede, B. M. (2017). Return to play after hamstring injuries in football (soccer): a worldwide Delphi procedure regarding definition, medical criteria and decision-making. *Br. J. Sports Med., 51*(22), 1583-1591. https://doi.org/10.1136/bjsports-2016-09720630.

Woods, C., Hawkins, R. D., Maltby, S., Hulse, M., Thomas, A., & Hodson, A. (2004). The Football Association Medical Research Programme: an audit of injuries in professional football—analysis of hamstring injuries. *Br. J. Sports Med.*, *38*(1), 36-41. https://doi.org/10.1136/bjsm.2002.002352.

DOI 10.26773/mjssm.230305