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Ultrasound-guided percutaneous needle electrolysis and rehabilitation and reconditioning program following a hamstring injury reduces "return to play" time in professional soccer players: A case series

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Abstract

This case series follows the treatment protocol after a grade 2 injury to the proximal semitendinosus muscle using US-guided Percutaneous Needle Electrolysis (PNE) and Rehab & Reconditioning program (RRP) in two professional soccer players. The injury was diagnosed using magnetic resonance imaging (MRI) and ultrasound imaging. The players received one session of PNE 48 hours after the injury. The indoor's phase of the RRP started 24 hours after the PNE technique and then the player proceeded to perform an on-field's phase, following which the players returned to train with the team. The effectiveness of the program was measured by comparing the match-performance data collected through Global Positioning System (GPS) in two matches before and five matches after injury and with ultrasound imaging analyzing the evolution of the muscle injury. No adverse effects were identified during or after the US-Guided PNE technique. Both players missed a single competitive game because of injury (layoff= 16 and 14 days). The GPS variables studied showed similar values before and after injury. PNE and PRR protocol improves the results of the initial phase of muscle repair and reduces the time to return to training and return to play, maintaining the GPS parameters that the players need in high performance.

Keywords
- hamstring injury
- percutaneous needle electrolysis
- exercise
- professional soccer
- return to play

Introduction

Muscle injuries are among the most frequent injuries in sport.[1] In professional soccer, it continues to be a major problem due to the loss of competition and training and has a high recurrence rate.[2–4] For this reason, it constitutes a challenge with respect to treatments.[5–7]

Ultrasound (US)-guided Percutaneous Needle Electrolysis (PNE) is a minimally invasive technique that consists of the application of a galvanic current through an acupuncture needle.[8] This treatment stimulates a local inflammatory response leading to increased cellular activity and repair of the affected area.[9] The needle is directed at the soft tissue injuries of the musculoskeletal system under direct

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ultrasound visualization. PNE has proven to be effective in tendinosis,[10] plantar fasciitis,[11] whiplash syndrome,[12] and myofascial pain syndrome[13] however, its effectiveness in acute muscle injury is little known.[14,15]

Hamstring strains are one of the most common types of acute muscle injuries in nearly all forms of team and individual sports involving the lower body, especially in soccer.[16] The hamstring muscle strain-type injury is considered to be a multifactorial problem.[17] Given the high re-injury rate,[18] many authors have suggested using a sport-specific approach in the rehabilitation phase to ensure an optimal return-to-play scenario, permitting the player to perform at pre-injury levels without pain and maintain performance, and at the same time reduce the risk of reinjury.[19] Although many return-to-play programs have been reported in the literature,[20] to the best of our knowledge there are no soccer-specific programs dealing with rehabilitation following an injury to a muscle of the hamstring muscle group that integrates PNE and Rehab & Reconditioning Program (RRP).

Cases Study Description

Participants

Two male professional soccer players, belonging to one of the top ten first division teams in Spain were observed for this study during 2017–2018 seasons. One of the players played as a full-back (Player A: 30 year old Caucasian male, body mass = 72.1 kg; height = 1.72 m), whereas the other played in the center-back position (Player B: 26 year old African male, body mass = 71.8 kg; height = 1.75 m). Both players had suffered an indirect injury to the proximal semitendinosus muscle during in-competition matches. The players signed an informed consent and were also informed of their right to withdraw from the study at any given time. The ethics committee of The Technical University of Madrid (UPM) approved the study.

In both cases, the injury was diagnosed using magnetic resonance imaging (MRI) and ultrasound scanning within 48 hours of sustaining the injury. According to Peetrons' classification system,[21] both injuries were classified as a grade 2 semitendinosus muscle injury located at the proximal myotendinous junction.

The initial ultrasound examination detected a minor muscle fiber disruption (<5cm, Maximum Cross-sectional Area [CSA] ~10%), architectural distortion and edema surrounding without fluid collection/hematoma drainable (►**Fig. 1-A**). An intervention program was applied that included PNE and RRP.

The evolution of the injured muscle area was monitored every three days by ultrasound, with the help of GE LOGIQ™ Compare Assistant software to compare prior exams with current exams for confidence.

US-Guided Percutaneous Needle Electrolysis (PNE)

The players received one session of US-Guided PNE 48 hours after the injury. The PNE technique was performed under US guidance on the muscle injury using an intensity of 2 mA during 3s, five times (2:3:5), according to the protocol by Valera & Minaya.[22] A specifically developed medically certified device (Physio Invasiva®, PRIM Physio, Spain) was used (►**Fig. 2**). The device produced a continuous galvanic current through the cathode (modified electrosurgical scalpel with

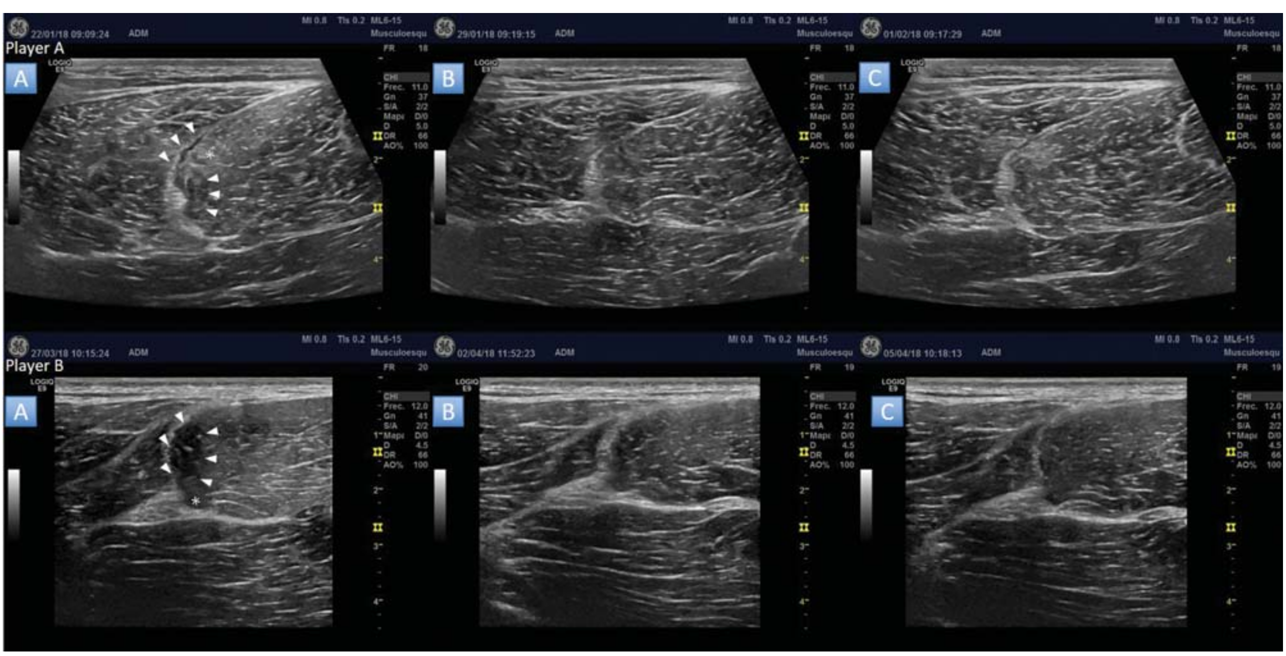

Fig. 1 Transverse B-Mode Ultrasound Images of the evolution of the injured muscle. (**A**) Initial. 48 hours post-injury. Ultrasound imaging shows muscle fiber discontinuity at the level of tear (arrowhead), with surrounding echogenic muscle edema (asterisk). (**B**) Ultrasound imaging during the Indoor Phase. (**C**) Ultrasound imaging during the On Field Phase.

Fig. 2 Medically certified device (Physio Invasiva®, PRIM Physio, Spain). (**A**) Device. (**B**) Cathode (modified electrosurgical scalpel with the needle). (**C**) Needle holder. (**D**) Needle. (**E**) Anode (handheld electrode).

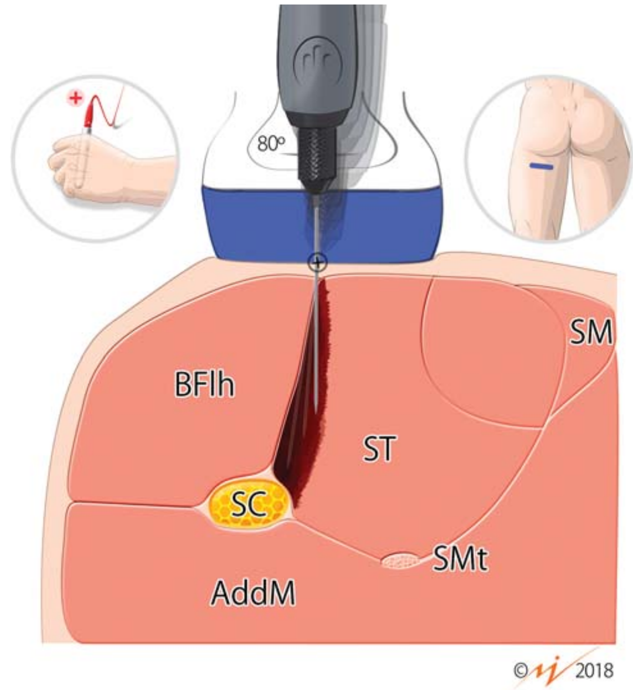

Fig. 3 PNE technique for proximal hamstring muscle injury. Abbreviations: AddM, Adductor Magnus; BFlh, Biceps Femoral long head; SM, Semimembranosus; SMt, Semimembranosus tendon; SN, Sciatic Nerve; ST, Semitendinosus. (by Valera-Garrido F, Minaya-Muñoz F. Electrolisis percutánea musculoesquelética. 1st ed. Barcelona: Elsevier; 2020, in press, with permission).

the needle) while the patient held the anode (handheld electrode). A GE Logiq E9 ultrasound machine with a ML6–15 lineal transducer (GE Healthcare, Wisconsin, USA) was used. During PNE intervention, the player was placed in the prone position with his feet outside the table. Prior to inserting a needle, the underlying skin was cleaned with isopropyl alcohol and chlorhexidine (Lainco® 2%). The transducer enclosed in a non-sterile rolled latex covers with non-sterile ultrasound gel was placed on the target area. Subsequently, an acupuncture needle 0.30 mm × 50 mm (Physio Invasiva® needles, PRIM Physio, Spain; uncoated steel needle with rigid metal handle with guide, Korean type) was inserted using a short axis approach, perpendicular to the surface of the skin, until the muscle injury according to the technique described by Valera & Minaya (►**Fig. 3**).[23] A physiotherapist with over 10 years' experience in ultrasound evaluation and 15 years' experience in invasive therapy applied the PNE technique. Oral paracetamol was used when necessary for the purpose of pain relief in the first 24 hours after PNE intervention.

The soccer players were asked to report any adverse events that they experienced during or after the PNE intervention. Adverse events can be defined as sequelae of medium to long term in duration, with moderate to severe symptoms, perceived as distressing and unacceptable and requiring further treatment.[24]

Rehab and Reconditioning Program (RRP)

The program was divided into 2 phases depending on the evolution of the participants during recovery. The phases were: a) Indoor phase; b) On Field phase.

Indoor's Phase

The RRP was adapted from Jiménez-Rubio et al[25] (►**Table 1**) and started 24 hours after the application of the PNE technique. They were initially subjected to controlled mobilizations to achieve a full hip and knee range of motion, and isometric activations of the lower limb muscles focusing on the primary hip extensor, the gluteus maximus.[26] Following this, dynamic drills were initiated in controlled ranges, while avoiding simultaneous hip flexion and knee extension. Such drills included lateral displacements in the frontal plane and hip extensor movements. Gradually, the velocity and weight in such drills were increased, and multi-planar displacements with and without external loads (such as sled pushes[27]) were introduced. This was followed by asymmetric exercises with an emphasis on the strengthening of the injured limbs (pelvic slide and elevation, deadlift from a height, single leg squats etc.). When the player was able to perform these activities and when the ultrasound imaging confirmed a correct alignment of muscle fibers without evidence of edema (►**Fig. 1-B**), the player was allowed to perform the on-field exercise program.

On-field's Phase (Soccer Field Grass)

After successfully completing the indoor program, the players continued to re-train via exercise on the field (►**Table 1**). These sessions were arranged with a progressive increase of difficulty. First, the players had to perform sprints of 8–14 m with and without changes of direction (randomized) and decelerations (total time <12 second , followed by shooting at a mini-goal 12 m away. The players then had to perform

Table 1 Items of the rehab and reconditioning program (RRP)

Program	Phase	Description
Rehab & Reconditioning Program	Indoor Phase	– Controlled mobilizations to achieve a full hip and knee range of motion, and isometric activations of the lower limb muscles focusing on the gluteus maximus as principal extensor in acceleration patterns. – Dynamic drills were initiated in controlled ranges, while avoiding simultaneous hip flexion and knee extension. – Displacements with and without external loads sled push, absorption and transmission forces. – Asymmetric exercises with an emphasis on the strengthening of the injured limbs (pelvic slide and elevation, deadlift from a height, single leg squats, Bulgarian squats). – Strength training in isometric + stretch-shortening cycle with multiplanar skills.
	On Field Phase	– Specific sports drills with sprints of 8–14 m with and without changes of direction (randomized) and decelerations (total time <12 second, followed by kicking at a mini-goal 12 m away. – Accelerations with sled towing using a 10 kg disc over a distance of 20 m. This was performed in the 1–2-1 sequence with 8s of rest between sequences with an optional kicking drill after the sets. – Specific sports drills (with and without the ball) including Repeated Sprint Ability (RSA) drills (distance> 14 m) with patterns of deceleration/stopping, changes of direction, pivoting, landing, cushioning and repetition. – Similar actions to the injury mechanisms at high velocities without external contact. Each drill lasted a maximum of 15s with an incomplete recovery (<30s).

Progression Criteria Indoor to On Field phase.
When the ultrasound imaging confirmed a correct alignment of muscle fibers without evidence of edema (►**Fig. 1-B**), and when participants were able to perform multiplanar-level movements with thrusts and different acceleration patterns without pain.
Progression Criteria On Field phase to return to training.
When the ultrasound imaging confirmed an optimal muscle repair (►**Fig. 1-C**) and when the participants passed the tasks of changes of direction, sprints, specific sport skills with uncertainty and repetition of efforts.

sled towing using a 10 kg disc over a distance of 20 m. This was performed in the 1–2-1 sequence with 8s of rest between sequences[28] with an optional kicking drill after the sets. The players also trained soccer specific drills (with and without the ball) including Repeated Sprint Ability (RSA) drills (distance> 14 m) with patterns of deceleration/stopping, changes of direction, pivoting, landing, cushioning and repetition.[29] Finally, toward the end of the phase on-field just before returning with the group, the players trained actions similar to the injury mechanisms at high velocities without external contact. Each drill lasted a maximum of 15s with an incomplete recovery (<30s).

Once the players successfully completed all the drills and when the ultrasound imaging confirmed an optimal muscle repair (►**Fig. 1-C**), they were declared to be available for selection and trained with the group.

GPS Match Variables Collected

For both players, GPS data (WIMU PRO™, Real Track Systems®, Almeria, Spain) was collected from all matches in which they participated. Both players played the entire duration of the matches (90 minutes) before and after injury. Data was obtained from two matches before the injury and five matches after (RTP-1 and four more matches). The variables used to compare the performance were: a) total distance covered; b) distance covered above 21km/h; c) distance covered between 14–21 km/h; d) peak velocity; e) peak acceleration; f) peak deceleration; g) explosive distance (distance covered when the acceleration exceeded 1.2 m/s^2) and h) work to rest ratio (ratio of the distance covered above 7 km/h to the distance covered under 7 km/h).

Results

From the time of the injury, Player A completed the first training (return to training) with the group on 14 days and subsequently competed officially on 16 days. Player B was able to complete tasks with the team on 9 days and played the first competition (return to play) on 14 days. No adverse effects were identified during or after the PNE technique. The players returned to play (►**Table 2**; RTP-1) registering GPS parameters which were similar to the values prior to the injury (►**Table 2**; PRE-2–1), maintaining the performance during the four matches following the intervention protocol (►**Table 2**; RTP-2–3-4–5). The players were followed up during eight months after the injury and neither of the players suffered a relapse during this period, which indicates the complete recovery of the injured muscle both on a structural and functional level, including optimal neuromuscular reprogramming.

Discussion

To the best of our knowledge, this is one of the first studies to describe the combined effect of PNE and RRP on muscle injuries in professional soccer players. The program appeared to have obtained excellent results as the results indicated an early return to sports activity. In this paper, GPS

Table 2 Data from GPS variables from in-competition matches before and after injury

	PRE2	PRE1	RTP1	RTP2	RTP3	RTP4	RTP 5
Player A							
Days (before and after injury)	−13	−7	16	23	31	37	40
Total distance (m)	11165.32	11002.9	10992.12	10985.23	11411.89	10874.34	11321.11
Total distance at V1(m)	1994.53	1978.93	1971.37	2131.02	2013.21	2111.89	2190.5
Total distance at V2(m)	488.92	582.14	380.93	468.98	510.21	543.21	651.49
Peak velocity (km/h)	31.81	33.95	29.63	32.78	31.9	32.12	30.74
Peak acceleration (m/s^2)	5.32	4.96	5.25	5.65	4.97	5.01	4.41
Peak deceleration (m/s^2)	−6.99	−7.96	−6.25	−6.23	−6.37	−6.12	−6.65
Explosive distance (m)	1611.91	1549.16	1390.73	1497.31	1297.34	1424.66	1531.3
Work to rest ratio	1.86	2.17	2.05	1.92	2.03	2.12	2.14
Player B							
Days (before and after injury)	−28	−21	14	22	25	28	36
Total distance(m)	9831.56	9678.12	9861.91	9987.65	9554.59	10177.12	9993.87
Total distance at V1(m)	1369.07	1034.96	797.00	1056.89	1314.27	1198.65	1284.52
Total distance at V2(m)	353.61	293.12	206.60	298.70	345.80	401.76	443.74
Peak velocity (km/h)	32.85	30.97	31.74	31.87	32.01	31.97	35.09
Peak acceleration (m/s^2)	5.36	5.32	5.28	5.43	3.59	5.12	5.25
Peak deceleration (m/s^2)	−6.07	−6.94	−5.39	−5.43	−4.68	−5.39	−6.73
Explosive distance (m)	1329.35	1197.34	1201.07	1224.87	490.23	1277.45	1301.96
Work to rest ratio	2.04	1.61	1.43	1.59	0.22	1.82	1.68

Abbreviations: PRE2 and PRE1, Pre-injury matches; RTP1, Return to play (1st match post-injury); RTP2, Return to play (2nd match post-injury), etc.; V1, Velocity between 14–21 km/h; V2, Velocity over 21 km/h.

parameters from the matches of two players were registered before and after having suffered an injury in the semitendinosus muscle. After sustaining the injury, the players were treated with PNE technique and subjected to an indoor and on-field RRP which allowed them to have a lower lay-off period and therefore they only missed a single competitive game, allowing them to return-to-play and registering parameters that were similar to pre-injury values, while sustaining the performance in the subsequent three matches.

Wangensteen et al.[30] analyzed the structural changes that occur during the first week after acute hamstring injury in professional and amateur athletes. The MRI examinations performed daily, did not show significant changes in the extent of edema and in the presence and extent of fiber disruption (tear). In the two cases presented in this study, the PNE technique and initial exercise changed the extent of edema and fiber disruption between day 1 and day 7 post-treatment as seen in the US scans (►**Fig. 1-B**). Muscle healing after a muscle injury follows a complex process including inflammation and proliferation. The results and images from the first 9–10 days (►**Fig. 1-C**) show that the combination of PNE and RRP improve the conventional results of the initial phase of muscle healing.

The scientific literature mentions a median lay-off period of 21 days for return to play after a Grade II semitendinosus muscle injury.[31] In the case of player A, he returned to play after 16 days and there were only 2 days between return to training and the match day. Player B returned to training in a period of just 9 days, adapting to group loads until return to play at 14 days. This player even played four matches within 28 days after suffering the injury (including three games in seven days, ►**Table 2**). There are samples of how the players were able to withstand the loads that the competition demands and shows the individual strengthening that they obtained during the intervention program. It is important to note that neither of the players suffered a reinjury in the eight months after sustaining injury. According to the model that the authors have developed, in elite sport, not only should the time since the injury be considered, rather, the changes in the structure and the level of task performance should be noted to determine when a player can return to train and play.

This case series shows the benefits of applying a combination of PNE and RRP to improve RTP times in elite soccer players. However, it is important to note that RTP also depends on technical decisions made by coaches, the scheduling of matches and the psychological readiness of the player.

The absence of a control group, the small sample size and the lack of final evaluation with MRI at discharge are the main limitations of the present study. The current research constitutes a pilot study that allows preliminary results of the present protocol (PNE + RRP). Looking ahead, it would be interesting to increase the sample size, analyze the results in other muscle groups, validate the protocol for other types of population (for example amateur player or human phenotype), and finally propose a clinical trial with a control group.

Conflict of Interests
The authors have no conflict of interests to declare.

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References

1 Garrett WE Jr. Muscle strain injuries. Am J Sports Med 1996;24(6, Suppl)S2–S8
2 Svensson K, Eckerman M, Alricsson M, Magounakis T, Werner S. Muscle injuries of the dominant or non-dominant leg in male football players at elite level. Knee Surg Sports Traumatol Arthrosc 2018;26(03):933–937
3 Ueblacker P, Müller-Wohlfahrt HW, Ekstrand J. Epidemiological and clinical outcome comparison of indirect ('strain') versus direct ('contusion') anterior and posterior thigh muscle injuries in male elite football players: UEFA Elite League study of 2287 thigh injuries (2001-2013). Br J Sports Med 2015;49(22):1461–1465
4 Eirale C, Farooq A, Smiley FA, Tol JL, Chalabi H. Epidemiology of football injuries in Asia: a prospective study in Qatar. J Sci Med Sport 2013;16(02):113–117
5 Huard J, Li Y, Fu FH. Muscle injuries and repair: current trends in research. J Bone Joint Surg Am 2002;84(05):822–832
6 Delos D, Maak TG, Rodeo SA. Muscle injuries in athletes: enhancing recovery through scientific understanding and novel therapies. Sports Health 2013;5(04):346–352
7 Bubnov R, Yevseenko V, Semeniv I. Ultrasound guided injections of platelets rich plasma for muscle injury in professional athletes. Comparative study. Med Ultrason 2013;15(02):101–105
8 Valera-Garrido F, Minaya-Muñoz F, Medina-Mirapeix F. Ultrasound-guided percutaneous needle electrolysis in chronic lateral epicondylitis: short-term and long-term results. Acupunct Med 2014;32(06):446–454
9 Valera-Garrido F, Minaya-Muñoz F, Sánchez-Ibáñez JM, et al. Comparison Of The Acute Inflammatory Response And Proliferation Of Dry Needling And Electrolysis Percutaneous Intratissue In Healthy Rat Achilles Tendons. Br J Sports Med 2013; 47(09):e2
10 Arias-Buría JL, Truyols-Domínguez S, Valero-Alcaide R, Salom-Moreno J, Atín-Arratibel MA, Fernández-de-Las-Peñas C. Ultrasound-Guided Percutaneous Electrolysis and Eccentric Exercises for Subacromial Pain Syndrome: A Randomized Clinical Trial. Evid Based Complement Alternat Med 2015;2015:315219
11 Iborra-Marcos Á, Ramos-Álvarez JJ, Rodriguez-Fabián G, et al. Intratissue Percutaneous Electrolysis vs Corticosteroid Infiltration for the Treatment of Plantar Fasciosis. Foot Ankle Int 2018;39 (06):704–711
12 García Naranjo J, Barroso Rosa S, Loro Ferrer JF, Limiñana Cañal JM, Suarez Hernández E. A novel approach in the treatment of acute whiplash syndrome: Ultrasound-guided needle percutaneous electrolysis. A randomized controlled trial. Orthop Traumatol Surg Res 2017;103(08):1229–1234
13 Lopez-Martos R, Gonzalez-Perez LM, Ruiz-Canela-Mendez P, Urresti-Lopez FJ, Gutierrez-Perez JL, Infante-Cossio P. Randomized, double-blind study comparing percutaneous electrolysis and dry needling for the management of temporomandibular myofascial pain. Med Oral Patol Oral Cir Bucal 2018;23(04):e454–e462
14 Valera-Garrido F, Minaya-Muñoz F, Sánchez-Ibáñez JM. Efecto de la electrólisis percutánea en las roturas musculares agudas. Caso clínico de la lesión de "tennis leg". II Congreso Regional de Fisioterapia de la Región de Murcia. Murcia, 2012
15 Santafe MM, Margalef R, Minaya Muñoz F, Valera Garrido F. Action of galvanic current on an experimentally generated muscle lesion: preliminary findings. J Invasive Tech Phys Therap 2019;2(02): 108–109
16 Ekstrand J, Hägglund M, Waldén M. Epidemiology of muscle injuries in professional football (soccer). Am J Sports Med 2011; 39(06):1226–1232
17 Freckleton G, Pizzari T. Risk factors for hamstring muscle strain injury in sport: a systematic review and meta-analysis. Br J Sports Med 2013;47(06):351–358
18 Ekstrand J, Waldén M, Hägglund M. 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 2016;50(12):731–737
19 Heiderscheit BC, Sherry MA, Silder A, Chumanov ES, Thelen DG. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. J Orthop Sports Phys Ther 2010; 40(02):67–81
20 Erickson LN, Sherry MA. Rehabilitation and return to sport after hamstring strain injury. J Sport Health Sci 2017;6(03): 262–270
21 Peetrons P. Ultrasound of muscles. Eur Radiol 2002;12(01):35–43
22 Valera-Garrido F, Minaya-Muñoz F. Fisioterapia Invasiva. 2ª ed. Barcelona: Elsevier; 2016
23 Valera-Garrido F, Minaya-Muñoz F. Electrolisis percutánea musculoesquelética. 1 ed. Barcelona: Elsevier; 2020, in press
24 Carlesso LC, Macdermid JC, Santaguida LP. Standardization of adverse event terminology and reporting in orthopaedic physical therapy: application to the cervical spine. J Orthop Sports Phys Ther 2010;40(08):455–463
25 Jiménez-Rubio S, Navandar A, Rivilla-García J, Paredes-Hernández V. Validity of an On-Field Readaptation Program Following a Hamstring Injury in Professional Soccer. J Sport Rehabil 2019; 28(04):325–331
26 Schuermans J, Danneels L, Van Tiggelen D, Palmans T, Witvrouw E. Proximal Neuromuscular Control Protects Against Hamstring Injuries in Male Soccer Players: A Prospective Study With Electromyography Time-Series Analysis During Maximal Sprinting. Am J Sports Med 2017;45(06):1315–1325
27 Petrakos G, Morin JB, Egan B. Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review. Sports Med 2016;46(03):381–400
28 Martínez-Valencia MA, Romero-Arenas S, Elvira JLL, González-Ravé JM, Navarro-Valdivielso F, Alcaraz PE. Effects of Sled Towing on Peak Force, the Rate of Force Development and Sprint Performance During the Acceleration Phase. J Hum Kinet 2015; 46:139–148
29 Stewart PF, Turner AN, Miller SC. Reliability, factorial validity, and interrelationships of five commonly used change of direction speed tests. Scand J Med Sci Sports 2014;24(03):500–506

30 Wangensteen A, Bahr R, Van Linschoten R, et al. MRI appearance does not change in the first 7 days after acute hamstring injury-a prospective study. Br J Sports Med 2017;51(14):1087–1092

31 Hallén A, Ekstrand J. Return to play following muscle injuries in professional footballers. J Sports Sci 2014;32(13): 1229–1236