U.PORTO
FMUP FACULDADE DE MEDICINA
UNIVERSIDADE DO PORTO

MESTRADO INTEGRADO EM MEDICINA

2017/2018

João Pedro Pereira Moutinho

Hamstring injuries in athletes: a current approach to the diagnosis and treatment

março, 2018

João Pedro Pereira Moutinho

Hamstring injuries in athletes: a current approach to the diagnosis and treatment

Mestrado Integrado em Medicina

Área: Medicina clínica - Ortopedia

Tipologia: Monografia

Trabalho efetuado sob a Orientação de:
Prof Doutor Manuel António Pereira Gutierres

Trabalho organizado de acordo com as normas da revista:
British Journal of Sports Medicine

março, 2018

FMUP FACULDADE DE MEDICINA
UNIVERSIDADE DO PORTO

Projeto de Opção do 6º ano - DECLARAÇÃO DE INTEGRIDADE

Eu, João Pedro Pereira Moutinho, abaixo assinado, nº mecanográfico 201201172, estudante do 6º ano do Ciclo de Estudos Integrado em Medicina, na Faculdade de Medicina da Universidade do Porto, declaro ter atuado com absoluta integridade na elaboração deste projeto de opção.

Neste sentido, confirmo que **NÃO** incorri em plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria de um determinado trabalho intelectual, ou partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores, foram referenciadas, ou redigidas com novas palavras, tendo colocado, neste caso, a citação da fonte bibliográfica.

Faculdade de Medicina da Universidade do Porto, 14/03/2018

Assinatura conforme cartão de identificação:

U.PORTO
FMUP FACULDADE DE MEDICINA
UNIVERSIDADE DO PORTO

Projecto de Opção do 6º ano – DECLARAÇÃO DE REPRODUÇÃO

NOME

João Pedro Pereira Moutinho

NÚMERO DE ESTUDANTE

201201172

E-MAIL

jpedromoutinho@gmail.com

DESIGNAÇÃO DA ÁREA DO PROJECTO

Medicina Clínica – Ortopedia

TÍTULO ~~DISSERTAÇÃO~~/MONOGRAFIA (riscar o que não interessa)

Hamstring Injuries in athletes: a current approach to the diagnosis and treatment.

ORIENTADOR

Manuel António Pereira Gutierres

COORIENTADOR (se aplicável)

ASSINALE APENAS UMA DAS OPÇÕES:

É AUTORIZADA A REPRODUÇÃO INTEGRAL DESTE TRABALHO APENAS PARA EFEITOS DE INVESTIGAÇÃO, MEDIANTE DECLARAÇÃO ESCRITA DO INTERESSADO, QUE A TAL SE COMPROMETE.	☐
É AUTORIZADA A REPRODUÇÃO PARCIAL DESTE TRABALHO (INDICAR, CASO TAL SEJA NECESSÁRIO, Nº MÁXIMO DE PÁGINAS, ILUSTRAÇÕES, GRÁFICOS, ETC.) APENAS PARA EFEITOS DE INVESTIGAÇÃO, MEDIANTE DECLARAÇÃO ESCRITA DO INTERESSADO, QUE A TAL SE COMPROMETE.	☐
DE ACORDO COM A LEGISLAÇÃO EM VIGOR, (INDICAR, CASO TAL SEJA NECESSÁRIO, Nº MÁXIMO DE PÁGINAS, ILUSTRAÇÕES, GRÁFICOS, ETC.) NÃO É PERMITIDA A REPRODUÇÃO DE QUALQUER PARTE DESTE TRABALHO.	☒

Faculdade de Medicina da Universidade do Porto, 19/03/2018

Assinatura conforme cartão de identificação: João Pedro Pereira Moutinho

Gostaria de agradecer ao Prof. Doutor Manuel Gutierres pela orientação, conhecimento e tempo disponibilizado a este projeto.

Quero também agradecer ao Kavi Gosai por ler e corrigir o texto e ao Gonçalo Sobral pelas tabelas.

Por fim, um grande obrigado à minha família e amigos pelo apoio e paciência ao longo de todo o projeto.

TITLE

Hamstring injuries in athletes: a current approach to the diagnosis and treatment – a narrative review

Corresponding author

João Pedro Pereira Moutinho

São João Medical Centre - Porto Medical School (Faculdade de Medicina da Universidade do Porto)

Address: Rua Infante D. Henrique, 617, 4435-286 Rio Tinto, Portugal

E-mail: jpedromoutinho@gmail.com

Telephone number: (+351) 916937517

Co-Authors

Manuel António Pereira Gutierres, MD PhD

Orthopedic Surgeon

Knee and Shoulder Group - Orthopedic Department

São João Medical Centre - Porto Medical School (Faculdade de Medicina da Universidade do Porto)

Word count

3278 words

ABSTRACT

Muscle injuries are the most frequent traumas occurring in sports, and among those, the hamstrings are the most commonly affected. Hamstring injuries often cause pain and dysfunction, as well as the inability to return to practice and competition. The severity of the injury determines the management and the amount of time an athlete must take off, which can be very costly to his career. An appropriate diagnosis and treatment is crucial for optimizing the recovery and minimizing the time spent inactive. Most injuries have an indication for being managed conservatively and studies have shown very positive outcomes. The use of growth factors to aid muscle rehabilitation has been growing in popularity – Platelet-rich plasma, platelet-rich fibrin and corticosteroids have been the subject of many recent studies on this matter. Up to this point, platelet-rich plasma has shown the most promising results in aiding the non-operative treatment. The rehabilitation should be injury tailored and have a progressive increase in intensity, range of motion and eccentric resistance, and end with neuromuscular control and sports specific exercises. In this article, we set to review the current approach to diagnosing and managing a hamstring injury in athletes.

INTRODUCTION

Hamstring injuries are among the most frequent lower limb trauma occurring in sports, affecting both professional and amateur athletes.[1-3] These have become a matter of rising importance because the time off an athlete must take from his career is very costly for himself and his team and can affect his future performance.[4] Hamstring injuries can be any strain or tear of any of the muscles or tendons within the hamstring group. Despite being a common injury, the optimal treatment is still controversial and is heavily dependent on the severity of the injury. This review summarizes the epidemiology, risk factors, anatomy and physiology, before tackling the current approach to diagnosing and treating the injury.

EPIDEMIOLOGY

Hamstring injuries are a common factor in most prolonged pauses from training and competition in athlete's careers and usually more than one muscle is involved.

Anatomically, hamstring injuries occur most frequently in the myotendinous junction, where muscle and tendon fibres intersect.[5] Injuries are most likely to occur when hamstrings are stretched – hip flexion combined with knee extension – during eccentric contraction, therefore they are more prevalent in sports such as soccer, football, running and water-skiing, where sprinting, running and/or rapid changes of direction are required.[3, 6, 7] Hamstring strains and partial tear are the most frequently occurring form of injury, whereas complete ruptures are less common.[8] Less frequent are avulsion injuries, where the hamstring tendon tears from the bone. Proximal injuries are more common than distal injuries regardless of which muscles are involved.[9]

ANATOMY AND PHYSIOLOGY

Hamstrings consist of 3 muscles: semimembranosus, semitendinosus, and biceps femoris with its long and short head. To understand the anatomy and the physiology predisposing the injuries, it is necessary to know the hamstrings act as hip extenders and knee flexors. During locomotion, the hamstrings are involved in extension, flexion and stabilization of the knee and hip, since all these muscles, except the short head of the biceps femoris, cross both joints.[10] All 3 muscles have the same point of origin on the ischial tuberosity. The semitendinosus and semimembranosus both descend along the medial portion of the thigh to insert on the pes anserinus and posteromedial portion of the tibia, accordingly. The long and short heads of the biceps femoris have their insertion mostly on the fibular head.[5]

All the hamstring muscles are innervated by the tibial portion of the sciatic nerve except for the short head of the biceps, which is innervated by the peroneal branch.

RISK FACTORS

Risk factors for hamstring can be categorized as modifiable and nonmodifiable.[11-13]

Modifiable risk factors include inadequate warm-up, increased training volume, muscle fatigue, hamstring stiffness and inflexibility, and hamstring weakness relative to the quadriceps. Non-modifiable risk factors include previous hamstring or lower limb muscle injury, older age and African or Aboriginal ethnic origin.[14] In athletes, especially soccer and football players, speed and kicking positions also increase the risk of injury. Previous hamstring injury is the most preponderant risk factor and is associated with the highest rate of reinjury, depending on the size and severity of the initial injury.[15] This is thought to be caused by architectural changes in the muscle, where normal muscle tissue is replaced by scar tissue.[5]

CLINICAL PRESENTATION

The clinical presentation of a hamstring injury may vary depending on the grade, location, and mechanism of injury.

An acute hamstring injury usually presents itself with an abrupt, sharp pain in the posterior aspect of the thigh, which can be associated with the onset of ecchymosis.[16] This sudden pain can be concomitant to an audible pop and a substantial loss of strength in the affected limb. Following this injury, patients may avoid movements such as hip and knee flexion to reduce pain, and load bearing will be affected. This makes it very difficult to continue sporting activities and, in some cases, common every day activities such as walking, sitting and standing up will be affected.[5, 17-19]

In case of a complete tear of the myotendinous junction, there may be palpable muscle defects, such as lumps, associated to ecchymosis. These can be felt and seen upon contraction.[3]

Patients with an isolated biceps femoris rupture may feel localized pain in the lateral or posterolateral area of the thigh.[20]

Patients who suffer mild strains are less likely to seek medical attention since the symptoms typically are alleviated within a few days following the injury.[19]

GRADING SYSTEM

Hamstring injuries have traditionally been classified in 3 grades based on severity: Grade I, Grade II and Grade III.[21]

Grade I injuries account for a strain of the muscle fibres. Grade II are partial tears of the muscle and/or tendon, they are presented with pain and noticeable loss of strength. Grade III is a complete tear of the musculotendinous unit with complete loss of function, typically accompanied with pain and a large haematoma.

Additionally, for description purposes, injuries can be classified based on their anatomical location – from proximal to distal – as well their degree of avulsion.[1, 9] These scales aren’t however widely spread and therefore not very used.

DIAGNOSIS

The diagnostic process should begin with a patient interview, asking about the context in which the injury occurred, pattern of the pain and how symptoms affect day-to-day activities as well as sports practice. Then, it should be followed up by a thorough physical examination and medical imaging if required.

Physical examination

Like in every other musculoskeletal injury, inspection, palpation, range of motion and strength should be assessed. Firstly, gait abnormalities, such as limping and reduced hip movements, should be noticed. Patients should then lie in the prone position, where each of the three hamstring muscles should be palpated from origin to insertion, particularly the origin at the ischial tuberosity, to check for avulsion. However, due to their deep location, it is often difficult to determine the exact nature of the injury upon physical examination.[8, 20, 22] Hamstring injuries typically manifest themselves with swelling and ecchymosis localized to the posterior side of the thigh and, in cases of a more extensive injury, haematoma. Range of motion and strength of the affected hamstring muscle should be examined by testing knee flexion with resistance applied at the heel, with the knee at 15° and 90° of flexion to evaluate eccentric and concentric contractions, accordingly. Testing shall be performed on both sides and comparing it to the contralateral, uninjured, side is of the utmost importance. Weakness and pain noticed during examination are positive findings and should be followed by further examination with the resource of medical imaging.[3, 22]

Medical imaging

Diagnostic imaging in hamstring injuries should start with ultrasonography. It is accessible, inexpensive, innocuous and has great sensitivity towards these injuries during the acute phase, when fluid can be found in the soft tissue.[5] It is however a very operator dependent test and doesn't provide very detailed image, becoming less accurate over time.

The gold standard for diagnosing hamstring injuries is magnetic resonance imaging (MRI).[3, 8] It is crucial when assessing the amount of soft tissue involved as well as the location and extent of the injury, differentiating partial from complete muscle tear, number of tendons involved and amount of retraction. MRI findings are, therefore, very helpful when making the decision of whether to go for a surgical treatment, in addition to being very useful for estimating recovery time by measuring and correlating the length and cross-section area of the injury, as studied by Cohen et al., in a trial conducted with professional football players that suffered acute hamstring injuries.[23] The authors created a predictive MRI scoring table, which included the age of the patient, number of muscles injured, location of injury within the muscle, percentage of muscle involved, extent of retraction and T2 signal length, each parameter scoring up to 3 points (table 1).[23]

Table 1: MRI scoring system [23]

Points	*Age (years)*	*Muscles involved (Number)*	*Location*	*Insertion*	*Muscle Injury (%)*	*Retraction (cm)*	*Long Axis T2 Signal Length (cm)*
0				No	0	None	0
1	≤ 25	1	Proximal		25	< 2	1 to 5
2	26 to 31	2	Middle	Yes	50	≥ 2	6 to 10
3	≥ 32	3	Distal		≥ 75		> 10

Patients whose scores were above 15 were found to have a delayed recovery, whereas those with scores below 10 missed none or one game. The longest recoveries were associated with patients with multiple muscle injuries, percentage of muscle involvement greater than 75%, T2 sagittal plane signal longer than 10 cm and over 2 cm of retraction.

Orthopaedic injuries tend to be diagnosed with the help of radiographs, but in what regards hamstring injuries, these will only be of diagnostic use in case of an avulsion fracture of the ischial tuberosity.[3]

TREATMENT

Hamstring injury is treated depending on the location and severity of the tear. Patients with an injury in the myotendinous junction should be treated differently than patients with avulsion type injuries.[24] Treatment can be either surgical or a more conservative non-surgical approach.

Non-operative treatment

Most hamstring injuries respond well to conservative management. The main priority of the non-surgical treatment is to control the pain and decrease inflammation caused by the acute injury. There is, however, no full consensus on what the conservative treatment should consist in.[22, 25]

The most agreed on and valid treatment is RICE – rest, ice, compression, elevation. It restrains the initial inflammatory response and helps control edema and haemorrhage. Despite that, recent studies have exposed its limitation. One of the main concerns is that a long resting phase longer than 72 hours can lead to a bigger loss of muscle strength and flexibility and can delay the return to normal function. It is thought that an earlier and gradual return to activity is related to a rapid recovery.[26] Consequently, the POLICE protocol – protection, optimal load, ice, compression, elevation – has shown better results.[27] Optimal load means gradually replacing rest with a balanced and incremental amount of physical activity. This also contributes towards better regeneration and orientation of the injured muscle fibres.[27, 28] Protection provided by crutches, braces or other supports is also highly recommended to avoid further injury to the affected site.

It is necessary to point out that the non-surgical approach to treating hamstring injuries is dependent on its severity – for example, more extensive injuries to the muscle and soft tissue may experience a longer period of recovery.[8, 24] Considering this high discrepancy, there isn't a fixed time protocol that can be applied, but rather a recovery program tailored to the patient's symptoms and level of pain, to ensure an adequate rehabilitation, focusing on strengthening and regain of function. Returning to activity prematurely may submit patients to a high risk of reinjury.[22, 29]

Nonsteroidal anti-inflammatories are generally recommended and should be prescribed to reduce inflammation and pain perception in the earlier stages of the injury. It is effective at managing pain in most injuries and has shown to reduce inflammatory reactions with no harm to tissue healing in that period. For long-term use, however, it is thought that NSAID usage can delay muscle regeneration.[22, 30]

Corticosteroid intramuscular injections in hamstring injuries hasn't been widely studied and there is lack of strong evidence supporting this treatment. Despite that, Levine et al. performed a study on football players with grade II hamstring injuries, over the course of 13 years.[31] Players were capable of returning to a preinjury level of competition in a mean of 7.6 days, while reporting no side effects or negative outcomes. Although there were no controls on this study, it has shown a very promising outlook for the role of corticosteroids. Other studies have exposed, however, both favourable and unfavourable effects on the recovery of the injured muscles so this method remains controversial, since there are potential side effects of injecting corticosteroids into injured muscles.[32, 33]

Platelet-rich plasma (PRP) is currently being investigated for its effectiveness in speeding the healing of hamstring injuries. To produce PRP, a double spin of the patient's whole blood is required,[34] but despite its increase in popularity, clinical evidence to define the preferred method regarding the injectable volume, timing of the application and number of injections is lacking.[33, 35] The argument for the use of PRP relies on the theory that growth factors and cytokines released by the platelets would enhance the natural recovery process. PRP also has an established pain-relieving effect provided.[36]

There are a few randomized controlled tests that have investigated the effect of PRP injections in hamstring injuries. End results vary, but the lack of secondary and deleterious effects was transversal to all trials.[33] Bubnov et al. performed a study with thirty grade 2 hamstring injuries, split into two groups.[37] One control group who received standard conservative treatment and another group receiving a PRP injection plus the same conservative treatment. Pain, muscle function and range of motion were significantly improved in the first three weeks of treatment, whereas in the fourth week results were similar. The average time to return to activity was 10 ± 2 days in the group that received the PRP treatment, compared to 22 ± 1.5 days in the control group. Hamid et al. conducted a trial with 28 patients with Grade 2 hamstring muscle injuries divided into two groups.[36] One group received a standard rehabilitation, while the other group had the same rehabilitation in addition to a 3ml PRP injection administrated to the injured area with ultrasound guidance. Those who received the PRP injection achieved had a significantly faster recovery period than those in the standard rehabilitation group with an average return to play time of 26.7 ± 7.0 days, as opposed to the 42.5 ± 20.6 of the control group. As reported before, during the length of the trial, significantly lower pain levels were registered in the group treated with PRP.

We found one randomized controlled test, where PRP was no better than placebo injection. Reurink et al. performed a double-blind placebo-controlled test with 80 professional and recreational athletes with acute hamstring injuries.[38] One group was administered a 3 ml injection of PRP and the other group an isotonic saline as a placebo, within 5 days of initial injury. A second dose was administered 5 to 7 days after the first injection. Both groups received the same progress-based rehabilitation treatment. In the end, both placebo and PRP groups took the same 42 days on average to return to pre-injury level of activity.

PRP contains a combination of growth factors such as vascular endothelial growth factor and transforming growth factor β, which are thought to be the responsible for muscle repair [33]. We expect that in the future it will be possible to pinpoint the factors with healing properties from those with less relevance and more trials are still required before it becomes a globally accepted treatment. Although PRP is no longer prohibited by the World Anti-Doping Agency (WADA), there are regulations on its administration.[39]

Platelet-Rich Fibrin (PRF) production is a more recent and simplified method, since it does not require the use of thrombin and anticoagulants, unlike PRP.[40] Here, after the first centrifugation, due to the lack of anticoagulants in these samples, a fibrin clot formation forms in the middle layer, which is then taken and centrifuged again. Upon administration, PRF provides a continuous release of growth factors throughout a 10-day period, as opposed to the immediate release in PRP injections.[41] Being relatively new method of treatment, there is still little evidence to allow full recommendation of PRF over PRP, but as of now it seems PRP can be recommended for fast delivery of growth factors whereas PRF is more adequate for long term release.

Physical therapy plays an important role in rehabilitation of hamstring injuries, despite the lack of a well-defined, evidence based, protocol. The approach and the exercises used may vary, but there are some general principles that should be followed (table 2).[22]

Table 2: Physical therapy for hamstring injury rehabilitation [22]

	Phase 1	*Phase 2*	*Phase 3*
Goals	- Protect scar development - Minimize muscle atrophy	- Regain pain-free, mid-range, hamstring strength - Increase movement speed progressively to develop neuromuscular control over the injured limb	- Symptom-free during all activities - Achieve normal concentric and eccentric hamstring strength through full range of motion and speeds
Protection	- Avoid excessive active or passive lengthening of the hamstrings	- Avoid end-range lengthening of the hamstrings muscles	- Avoid full intensity exercises if pain, tightness or stiffness are present
Ice	- 2 to 3 times a day	- Post-exercise, 10 to 15 minutes	- Post-exercise ice should be applied only if necessary, 10 to 15 minutes
Criteria for advancing to next phase	- Work normally without pain - Perform prone knee flexion with minimal resistance	- Moderate intensity jogging - Perform full-strength prone knee flexion without pain	- Perform full strength activities, have full range of motion and replicate sport specific movements near full speed, without pain, in order to return to sports.

Initial physical therapy should be managing the pain, reducing the edema and preventing muscle atrophy. Once the initial pain and swelling has subsided, it is acceptable to initiate physical exercises. It should focus firstly on regaining flexibility and only afterwards on strengthening the muscles.

Rehabilitation can be divided in three phases. In the first one, the goals are to protect scar development and minimize muscle atrophy. Excessive lengthening of the hamstrings, which would aggravate the initial lesion, should be avoided, and ice should be applied 2 to 3 times a day. Patients should develop the ability to walk and perform daily tasks without pain and perform prone knee flexion with minimal resistance. The second phase focuses on regaining pain-free, mid-range, hamstring strength, while still avoiding end-range lengthening of the muscles. Movement speed should be increased progressively to develop neuromuscular control over the injured limb. Ice should be applied 10 to 15 minutes after exercise. Before passing onto the next phase, patients should be capable of jogging in moderate intensity, as well as performing full strength prone knee flexion without pain. In the third and last phase, the patient's goal is to be symptom-free during all activities. Normal concentric and eccentric hamstring strength through full range of motion and speeds should be achieved. Patients should avoid full intensity exercises if pain, tightness or stiffness are present. Post-exercise ice should be applied only if necessary. To match the criteria for returning to sports, patients should be able to perform full strength activities, have full range of motion and replicate sport specific movements near full speed, without pain.[42, 43]

Other options such as ultrasound stimulation, cold and heat compressors, and massaging have been considered as treatments for hamstring injuries, but there are no studies with results to validate them as being better than placebo.[17, 19]

Operative treatment

The surgical treatment has three major indications (table 3).

Table 3: Indications for surgical treatment

Acute	- Injuries that occurred too proximally
	- Two or more muscles avulsed from their origin with ≥ 2 cm of retraction
Chronic	- Hamstring syndrome: scarred muscle tissue with possible compression of the sciatic nerve

Two of those are in acute circumstances: when complete ruptures of the hamstrings occur too proximally; or when two or more muscles are avulsed from their origin at the ischial tuberosity, with a retraction of 2 cm or greater.[8, 18, 44] Studies have reported that the non-operative treatment of these injuries is associated to a longer period of recovery with worse results, particularly noticeable during heavy activity. Patients who undergo surgical repair during the acute phase tend to be significantly more satisfied with the end results, having more efficient pain relief, better strength and endurance, and a quicker return to preinjury level of sport than patients who opt for nonoperative treatment.[45-47] Therefore, surgical treatment for acute complete proximal hamstring ruptures is highly recommended in elite athletes. A study has shown that athletically active patients who underwent surgery were able to return to sport in an average of 6 months.[45] Finally, when avulsion occurs with hamstring retraction, delaying the surgical treatment can lead to a more technically challenging surgery and could increase the occurrence of sciatic nerve symptoms.[9]

The chronic indication for surgery is hamstring syndrome. Patients who suffer from this syndrome have a history of chronic hamstring injuries, causing scarring of the tissues, which can compress the sciatic nerve upon muscle contraction.[15] Therefore, patients often report pain in the area bound to the ischial tuberosity, irradiating distally to the thigh – sciatic nerve symptoms. A study performed by Young and van Riet included 43 patients who underwent a surgical release for this diagnosis with very positive outcomes.[48] Patients who undergo the surgical treatment should then follow a very similar rehabilitation plan to the one listed for the conservative treatment (table 2).[22, 44]

CONCLUSIONS

There is still some controversy regarding the treatment and rehabilitation protocols for hamstring injuries in athletes, but some general principles can aid the orthopaedic surgeon in the decision-making process. Most injuries are managed conservatively with good and excellent results. Currently, PRP shows the most promising results in aiding non-operative treatment. Complete injury of all three hamstrings and proximal avulsions with 2 cm of retraction have the strongest surgical indication. The main goals of the rehabilitation protocol are to return the athlete to activity at a pre-injury level of performance and to minimize risk of reinjury, focusing on eccentric and proprioceptive exercises. Each individual should have an injury tailored rehabilitation plan. Further studies will help to define and optimize a protocol for the treatment and rehabilitation of these lesions.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Kavi Gosai for grammatically reviewing and proof reading the text, and Gonçalo Sobral for the making of the tables.

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

There were no competing interests.

1. Lempainen, L., et al., *Distal tears of the hamstring muscles: review of the literature and our results of surgical treatment.* Br J Sports Med, 2007. **41**(2): p. 80-3; discussion 83.
2. Lempainen, L., et al., *Clinical principles in the management of hamstring injuries.* Knee Surg Sports Traumatol Arthrosc, 2015. **23**(8): p. 2449-2456.
3. Clanton, T.O. and K.J. Coupe, *Hamstring strains in athletes: diagnosis and treatment.* J Am Acad Orthop Surg, 1998. **6**(4): p. 237-48.
4. Askling, C., J. Karlsson, and A. Thorstensson, *Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload.* Scand J Med Sci Sports, 2003. **13**(4): p. 244-50.

5. Ali, K. and J.M. Leland, *Hamstring strains and tears in the athlete.* Clin Sports Med, 2012. **31**(2): p. 263-72.
6. Thelen, D.G., et al., *Simulation of biceps femoris musculotendon mechanics during the swing phase of sprinting.* Med Sci Sports Exerc, 2005. **37**(11): p. 1931-8.
7. Chumanov, E.S., B.C. Heiderscheit, and D.G. Thelen, *The effect of speed and influence of individual muscles on hamstring mechanics during the swing phase of sprinting.* J Biomech, 2007. **40**(16): p. 3555-62.
8. Cohen, S. and J. Bradley, *Acute proximal hamstring rupture.* J Am Acad Orthop Surg, 2007. **15**(6): p. 350-5.
9. Wood, D.G., et al., *Avulsion of the proximal hamstring origin.* J Bone Joint Surg Am, 2008. **90**(11): p. 2365-74.
10. Beltran, L., et al., *The proximal hamstring muscle-tendon-bone unit: a review of the normal anatomy, biomechanics, and pathophysiology.* Eur J Radiol, 2012. **81**(12): p. 3772-9.
11. Copland, S.T., J.S. Tipton, and K.B. Fields, *Evidence-based treatment of hamstring tears.* Curr Sports Med Rep, 2009. **8**(6): p. 308-14.
12. Murphy, D.F., D.A. Connolly, and B.D. Beynnon, *Risk factors for lower extremity injury: a review of the literature.* Br J Sports Med, 2003. **37**(1): p. 13-29.
13. Gabbe, B.J., R. Branson, and K.L. Bennell, *A pilot randomised controlled trial of eccentric exercise to prevent hamstring injuries in community-level Australian Football.* J Sci Med Sport, 2006. **9**(1-2): p. 103-9.
14. Woods, C., et al., *The Football Association Medical Research Programme: an audit of injuries in professional football--analysis of hamstring injuries.* Br J Sports Med, 2004. **38**(1): p. 36-41.
15. Engebretsen, A.H., et al., *Intrinsic risk factors for hamstring injuries among male soccer players: a prospective cohort study.* Am J Sports Med, 2010. **38**(6): p. 1147-53.
16. Ahmad, C.S., et al., *Evaluation and management of hamstring injuries.* Am J Sports Med, 2013. **41**(12): p. 2933-47.
17. Chu, S.K. and M.E. Rho, *Hamstring Injuries in the Athlete: Diagnosis, Treatment, and Return to Play.* Curr Sports Med Rep, 2016. **15**(3): p. 184-90.
18. Lempainen, L., et al., *Proximal hamstring tendinopathy: results of surgical management and histopathologic findings.* Am J Sports Med, 2009. **37**(4): p. 727-34.
19. Alzahrani, M.M., et al., *Hamstring Injuries in Athletes: Diagnosis and Treatment.* JBJS Rev, 2015. **3**(6).
20. Fortems, Y., et al., *Isolated complete rupture of biceps femoris tendon.* Injury, 1995. **26**(4): p. 275-6.
21. Kujala, U.M., S. Orava, and M. Jarvinen, *Hamstring injuries. Current trends in treatment and prevention.* Sports Med, 1997. **23**(6): p. 397-404.
22. Heiderscheit, B.C., et al., *Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention.* J Orthop Sports Phys Ther, 2010. **40**(2): p. 67-81.
23. Cohen, S.B., et al., *Hamstring injuries in professional football players: magnetic resonance imaging correlation with return to play.* Sports Health, 2011. **3**(5): p. 423-30.
24. Askling, C., T. Saartok, and A. Thorstensson, *Type of acute hamstring strain affects flexibility, strength, and time to return to pre-injury level.* Br J Sports Med, 2006. **40**(1): p. 40-4.
25. Reurink, G., et al., *Therapeutic interventions for acute hamstring injuries: a systematic review.* Br J Sports Med, 2012. **46**(2): p. 103-9.
26. Jarvinen, T.A., et al., *Muscle injuries: optimising recovery.* Best Pract Res Clin Rheumatol, 2007. **21**(2): p. 317-31.
27. Bleakley, C.M., P. Glasgow, and D.C. MacAuley, *PRICE needs updating, should we call the POLICE?* Br J Sports Med, 2012. **46**(4): p. 220-1.

28. Goldman, E.F. and D.E. Jones, *Interventions for preventing hamstring injuries: a systematic review.* Physiotherapy, 2011. **97**(2): p. 91-9.
29. Thelen, D.G., et al., *Neuromusculoskeletal models provide insights into the mechanisms and rehabilitation of hamstring strains.* Exerc Sport Sci Rev, 2006. **34**(3): p. 135-41.
30. Reynolds, J.F., et al., *Non-steroidal anti-inflammatory drugs fail to enhance healing of acute hamstring injuries treated with physiotherapy.* S Afr Med J, 1995. **85**(6): p. 517-22.
31. Levine, W.N., et al., *Intramuscular corticosteroid injection for hamstring injuries. A 13-year experience in the National Football League.* Am J Sports Med, 2000. **28**(3): p. 297-300.
32. Beiner, J.M., et al., *The effect of anabolic steroids and corticosteroids on healing of muscle contusion injury.* Am J Sports Med, 1999. **27**(1): p. 2-9.
33. Laupheimer, M.W., A.D. Silva, and S. Hemmings, *Injection therapies in muscle injuries: A systematic review.* International Musculoskeletal Medicine, 2015. **37**(4): p. 170-177.
34. Dhurat, R. and M. Sukesh, *Principles and Methods of Preparation of Platelet-Rich Plasma: A Review and Author's Perspective.* J Cutan Aesthet Surg, 2014. **7**(4): p. 189-97.
35. Wetzel, R.J., R.M. Patel, and M.A. Terry, *Platelet-rich plasma as an effective treatment for proximal hamstring injuries.* Orthopedics, 2013. **36**(1): p. e64-70.
36. MS, A.H., et al., *Platelet-rich plasma injections for the treatment of hamstring injuries: a randomized controlled trial.* Am J Sports Med, 2014. **42**(10): p. 2410-8.
37. Bubnov, R., V. Yevseenko, and I. Semeniv, *Ultrasound guided injections of platelets rich plasma for muscle injury in professional athletes. Comparative study.* Med Ultrason, 2013. **15**(2): p. 101-5.
38. Reurink, G., et al., *Platelet-rich plasma injections in acute muscle injury.* N Engl J Med, 2014. **370**(26): p. 2546-7.
39. World-Anti-Doping-Agency., *The 2018 Prohibited List.* Montreal, Canada: WADA, 2018.
40. Giannini, S., et al., *Comparison between PRP, PRGF and PRF: lights and shadows in three similar but different protocols.* Eur Rev Med Pharmacol Sci, 2015. **19**(6): p. 927-30.
41. Kobayashi, E., et al., *Comparative release of growth factors from PRP, PRF, and advanced-PRF.* Clin Oral Investig, 2016. **20**(9): p. 2353-2360.
42. Schmitt, B., T. Tim, and M. McHugh, *Hamstring injury rehabilitation and prevention of reinjury using lengthened state eccentric training: a new concept.* Int J Sports Phys Ther, 2012. **7**(3): p. 333-41.
43. Silder, A., et al., *Clinical and morphological changes following 2 rehabilitation programs for acute hamstring strain injuries: a randomized clinical trial.* J Orthop Sports Phys Ther, 2013. **43**(5): p. 284-99.
44. Birmingham, P., et al., *Functional outcome after repair of proximal hamstring avulsions.* J Bone Joint Surg Am, 2011. **93**(19): p. 1819-26.
45. Klingele, K.E. and P.I. Sallay, *Surgical repair of complete proximal hamstring tendon rupture.* Am J Sports Med, 2002. **30**(5): p. 742-7.
46. Harris, J.D., et al., *Treatment of proximal hamstring ruptures - a systematic review.* Int J Sports Med, 2011. **32**(7): p. 490-5.
47. Shambaugh, B.C., et al., *A Comparison of Nonoperative and Operative Treatment of Complete Proximal Hamstring Ruptures.* Orthop J Sports Med, 2017. **5**(11): p. 2325967117738551.
48. Young, I.J., R.P. van Riet, and S.N. Bell, *Surgical release for proximal hamstring syndrome.* Am J Sports Med, 2008. **36**(12): p. 2372-8.

Narrative reviews

We consider narrative reviews of general topics of importance to the sports and exercise medicine clinician. Authors should clearly outline in their cover letter why a narrative review is appropriate rather than a systematic review.

All titles should include ‘a Narrative Review’.

Please include a summary box summarising in 3-4 bullet points ‘What is already known’ and ‘What are the new findings’.

Word count: up to 4000 words
Abstract: up to 250 words
Tables/illustrations: Maximum 6 tables and/or figures
References: up to 80
MCQs required

Formatting Guidelines

Title page

This is excluded for the journal *BMJ Quality and Safety* which operates triple-blind peer review.
The title page must contain the following information:

- Title of the article.
- Full name, postal address, e-mail and telephone number of the corresponding author.
- Full name, department, institution, city and country of all co-authors.
- Word count, excluding title page, abstract, references, figures and tables.

Keywords

Authors can usually opt to (or are required to) choose keywords relevant to the content of the manuscript during the submission process. This assists in the identification of the most suitable reviewers for the manuscript. The selected keywords should also be included in the abstract itself.

Manuscript format

The manuscript must be submitted as a Word document (*BMJ Case Reports* and *Veterinary Record Case Reports* request that authors submit using a template which should also be in Word format). PDF is not accepted.
The manuscript should be presented in the following order:

- Title page.
- Abstract, or a summary for case reports (Note: references should not be included in abstracts or summaries).
- Main text separated under appropriate headings and subheadings using the following hierarchy: BOLD CAPS, bold lower case, Plain text, Italics.
- Tables should be in Word format and placed in the main text where the table is first cited. Tables should also be cited in numerical order.
- Acknowledgments, Competing Interests, Funding and all other required statements.
- References. All references should be cited in the main text in numerical order.

Figures must be uploaded as separate files (view further details under the Figures/illustrations section). All figures must be cited within the main text in numerical order and legends should be provided at the end of the manuscript.

Online Supplementary materials should be uploaded using the File Designation "Supplementary File" on the submission site and cited in the main text.

Please remove any hidden text headers or footers from your file before submission.

Style

Acronyms and abbreviations should be used sparingly and fully explained when first used. Abbreviations and symbols must be standard. SI units should be used throughout, except for blood pressure values which should be reported in mm Hg. Whenever possible, drugs should be given their approved generic name. Where a proprietary (brand) name is used, it should begin with a capital letter.

Figures/illustrations

Images must be uploaded as separate files. All images must be cited within the main text in numerical order and legends must be provided (ideally at the end of the manuscript).

[Video: How to improve your graphs and tables]

Colour images and charges

For certain journals, authors of unsolicited manuscripts that wish to publish colour figures in print will be charged a fee to cover the cost of printing. Refer to the specific journal's instructions for authors for more information.
Alternatively, authors are encouraged to supply colour illustrations for online publication and black and white versions for print publication. Colour publication

online is offered at no charge, but the figure legend must not refer to the use of colours.

Detailed guidance on figure preparation

File types

Figures should be submitted in TIFF or EPS format. JPEG files are acceptable in some cases. A minimum resolution of 300 dpi is required, except for line art which should be 1200 dpi. Histograms should be presented in a simple, two-dimensional format, with no background grid.

For figures consisting of multiple images/parts, please ensure these are submitted as a single composite file for processing. We are unable to accept figures that are submitted as multiple files.

During submission, ensure that the figure files are labelled with the correct File Designation of “Mono Image” for black and white figures and “Colour Image” for colour figures.

Figures are checked using automated quality control and if they are below the minimum standard you will be alerted and asked to resupply them.
Please ensure that any specific patient/hospital details are removed or blacked out (e.g. X-rays, MRI scans, etc). Figures that use a black bar to obscure a patient’s identity are NOT accepted.

Tables

Tables should be in Word format and placed in the main text where the table is first cited. Tables must be cited in the main text in numerical order. Please note that tables embedded as Excel files within the manuscript are NOT accepted. Tables in Excel should be copied and pasted into the manuscript Word file.

Tables should be self-explanatory and the data they contain must not be duplicated in the text or figures. Any tables submitted that are longer/larger than 2 pages will be published as online only supplementary material.

Video: How to improve your graphs and tables

Multimedia files

You may submit multimedia files to enhance your article. Video files are preferred in .WMF or .AVI formats, but can also be supplied as .FLV, .Mov, and .MP4. When submitting, please ensure you upload them using the File Designation “Supplementary File – Video”.

References

Authors are responsible for the accuracy of cited references and these should be checked before the manuscript is submitted.

Citing in the text

References must be numbered sequentially as they appear in the text. References cited in figures or tables (or in their legends and footnotes) should appear at the end of the reference list to avoid re-numbering if tables and figures are moved around at peer review/proof stage. Reference numbers in the text should be inserted immediately after punctuation (with no word spacing)—for example,[6] not [6].
Where more than one reference is cited, these should be separated by a comma, for example,[1, 4, 39]. For sequences of consecutive numbers, give the first and last number of the sequence separated by a hyphen, for example,[22-25]. References provided in this format are translated during the production process to superscript type, and act as hyperlinks from the text to the quoted references in electronic forms of the article.
Please note that if references are not cited in order the manuscript may be returned for amendment before it is passed on to the Editor for review.

Preparing the reference list

References must be numbered consecutively in the order in which they are mentioned in the text.
Only papers published or in press should be included in the reference list. Personal communications or unpublished data must be cited in parentheses in the text with the name(s) of the source(s) and the year. Authors should request permission from the source to cite unpublished data.
Journals from BMJ use a slightly modified version of Vancouver referencing style (see example below, or download here). Note that The BMJ uses a different style.

BMJ reference style

List the names and initials of all authors if there are 3 or fewer; otherwise list the first 3 and add ‘et al.’ (The exception is the Journal of Medical Genetics, which lists all authors). Use one space only between words up to the year and then no spaces. The journal title should be in italic and abbreviated according to the style of Medline. If the journal is not listed in Medline then it should be written out in full.

Check journal abbreviations using PubMed
Check citation information using PubMed

Example references

Journal article
13 Koziol-Mclain J, Brand D, Morgan D, et al. Measuring injury risk factors: question reliability in a statewide sample. *Inj Prev* 2000;6:148–50.

Chapter in book

14 Nagin D. General deterrence: a review of the empirical evidence. In: Blumstein A, Cohen J, Nagin D, eds. Deterrence and Incapacitation: Estimating the Effects of Criminal Sanctions on Crime Rates. Washington, DC: National Academy of Sciences 1978:95–139.

Book

15 Howland J. Preventing Automobile Injury: New Findings From Evaluative Research. Dover, MA: Auburn House Publishing Company 1988:163–96.

Abstract/supplement

16 Roxburgh J, Cooke RA, Deverall P, et al. Haemodynamic function of the carbomedics bileaflet prosthesis [abstract]. *Br Heart J* 1995;73(Suppl 2):P37.

Electronic citations

Websites are referenced with their URL and access date, and as much other information as is available. Access date is important as websites can be updated and URLs change. The “date accessed” can be later than the acceptance date of the paper, and it can be just the month accessed.

Electronic journal articles

Morse SS. Factors in the emergency of infectious diseases. *Emerg Infect Dis* 1995 Jan-Mar;1(1). www.cdc.gov/nciod/EID/vol1no1/morse.htm (accessed 5 Jun 1998).

Electronic letters

Bloggs J. Title of letter. *Journal name* Online [eLetter] Date of publication. url eg: Krishnamoorthy KM, Dash PK. Novel approach to transseptal puncture. *Heart* Online [eLetter] 18 September 2001. http://heart.bmj.com/cgi/eletters/86/5/e11#EL1

Legal material

Toxic substances Contro Act: Hearing on S776 Before the Subcommittee of the Environment of the Senate Comm. on Commerce, 94th Congress 1st September (1975).
Washington v Glucksberg 521 US 702 (1997)

Law references

The two main series of law reports, Weekly Law Reports (WLR) and All England Law Reports (All ER) have three volumes a year.
For example:
Robertson v Post Office [1974] 1 WLR 1176
Ashcroft v Mersey Regional Health Authority [1983] 2 All ER 245
R v Clarence [1868] 22 QBD 23
Wimpey Construction UK Ltd v Poole (1984) Times, 3 May
There are good historical precedents for the use of square and round brackets. Since 1891, round ones have referred to the date of the report, square ones to the date of publication of the report. Apart from not italicising the name of the case, we use the lawyers' style; be careful with punctuation. Here are some more examples:
Caparo Industries plc v Dickman and others [1990] 1 All ER 568-608.
R v Clarence [1888] 22 QBD 23.
Finlayson v HMAdv 1978 SLT (Notes) 60
Block v Martin (1951) 4 DLR 121
Official Journal of the European Communities: at the top of the page it gives the No, vol, and page and, at the other side of the header, the date.
The abbreviation for the title is given in parentheses under the title. Jiggle these elements around to get, eg:
Council Directive of 14 June 1989. Offical Journal of the European Communities No L 1989 June 28:181/44-6. (89/831/EEC.

Digital Object Identifier (DOI)

A DOI is a unique string created to identify a piece of intellectual property in an online environment and is particularly useful for articles that are published online before appearing in print (and therefore have not yet been assigned the traditional volume, issue and page number references). The DOI is a permanent identifier of all versions of an article, whether raw manuscript or edited proof, online or in print. Thus the DOI should ideally be included in the citation even if you want to cite a print version of an article.

Find a DOI

How to cite articles with a DOI before they have appeared in print

1. Alwick K, Vronken M, de Mos T, et al. Cardiac risk factors: prospective cohort study. *Ann Rheum Dis*Published Online First: 5 February 2004. doi:10.1136/ard.2003.001234

How to cite articles with a DOI once they have appeared in print

1. Vole P, Smith H, Brown N, et al. Treatments for malaria: randomised controlled trial. *Ann Rheum Dis*2003;327:765–8 doi:10.1136/ard.2003.001234 [published Online First: 5 February 2002].

PLEASE NOTE: RESPONSIBILITY FOR THE ACCURACY AND COMPLETENESS OF REFERENCES RESTS ENTIRELY WITH THE AUTHOR.

Online only supplementary material

Additional figures and tables, methodology, raw data, etc may be published online only as supplementary material. If your paper exceeds the word count you should consider if any parts of the article could be published online only. Please note that these files will not be copyedited or typeset and will be published as supplied, therefore PDF files are preferred.

All supplementary files should be uploaded using the File Designation "Supplementary File". Please ensure that any supplementary files are cited within the main text of the article.

Some journals also encourage authors to submit translated versions of their abstracts in their local language, which are published online only alongside the English version. These should be uploaded using the File Designation "Abstract in local language".