



Original Article

Muscle injury: current perspectives and trends in Brazil^{☆,☆☆}



Diego Costa Astur^{*}, João Vítor Novaretti, Renato Kalil Uehbe, Gustavo Gonçalves Arliani, Eduardo Ramalho Moraes, Alberto de Castro Pochini, Benno Ejnisman, Moises Cohen

Paulista Medical School, Federal University of São Paulo (UNIFESP), São Paulo, SP, Brazil

ARTICLE INFO

Article history:

Received 3 October 2013

Accepted 31 October 2013

Available online 27 October 2014

Keywords:

Muscle injury

Perspectives

Treatment

Management

Epidemiology

ABSTRACT

Objective: To evaluate the management, procedures and perspectives of sports physicians and orthopedists in Brazil with regard to diagnosing and treating muscle injuries.

Methods: A questionnaire containing 20 questions relating to the topic of muscle injury was applied to sports physicians and orthopedists during the Second Brazilian Congress of Arthroscopy and Sports Traumatology, in 2013.

Results: Completely answered questionnaires were received from 168 sports physicians and orthopedists. Doctors from all regions of Brazil with a mean of 11 years of experience of treating muscle injuries were interviewed. Lower limbs were affected in 97% of the cases, particularly the quadriceps, adductor and sural triceps. The injury occurred during the eccentric phase in 62% of the interviews; 39% underwent ultrasound examination and 37% magnetic resonance imaging (MRI) for the injury to be diagnosed. Medication, rest and cryotherapy during the acute phase (87.5%) and medication, rest and physiotherapy during treatment of the injury (56%) were the prevalent options. The criteria for returning to sports were very subjective and disparate among the options presented, and most of the interviewees had already used some therapy that was adjuvant to traditional methods.

Conclusion: The number of muscle injuries treated per year was greater than 30, independent of whether in the public or private sector. These injuries occurred mainly at the muscle-tendon junction, in the lower limbs and during the eccentric phase of muscle contraction. Ultrasound was the examination most performed, while MRI was considered ideal. For most of the interviewees, the preferred treatment involved rest, medication and physiotherapy. In addition, 52% believed that platelet-rich plasma was an efficient treatment and 42% said that they had already used it.

© 2014 Sociedade Brasileira de Ortopedia e Traumatologia. Published by Elsevier Editora Ltda. All rights reserved.

[☆] Please cite this article as: Astur DC, Novaretti JV, Uehbe RK, Arliani GG, Moraes ER, de Castro Pochini A, Ejnisman B, Cohen M. Lesão muscular: perspectivas e tendências atuais no Brasil. Rev Bras Ortop. 2014;49:573-580.

^{☆☆} Work developed at the Sports Traumatology Center, Department of Orthopedics and Traumatology, Paulista Medical School, Federal University of São Paulo (Unifesp), São Paulo, SP, Brazil.

^{*} Corresponding author.

E-mail: mcastur@yahoo.com (D.C. Astur).

<http://dx.doi.org/10.1016/j.rboe.2013.10.003>

2255-4971/© 2014 Sociedade Brasileira de Ortopedia e Traumatologia. Published by Elsevier Editora Ltda. All rights reserved.

Lesão muscular: perspectivas e tendências atuais no Brasil

R E S U M O

Palavras-chave:
Lesão muscular
Perspectivas
Tratamento
Conduta
Epidemiologia

Objetivo: Avaliar as condutas, os procedimentos e as perspectivas do médico do esporte e ortopedista do Brasil no diagnóstico e no tratamento de lesões musculares.

Métodos: Questionário com 20 questões relacionadas ao tema lesão musculares. Foi aplicado em médicos do esporte e ortopedistas durante o II Congresso Brasileiro de Artroscopia e Traumatologia do Esporte, em 2013.

Resultados: Responderam completamente o questionário 168 médicos do esporte e ortopedistas. Foram entrevistados médicos de todas as regiões do Brasil, com média de 11 anos de experiência no tratamento da lesão muscular. Membros inferiores são acometidos em 97% dos casos, principalmente quadríceps, adutor e tríceps sural. A lesão ocorre na fase excêntrica para 62% dos entrevistados, 39% fazem ultrassom (USG) e 37% ressonância magnética (RM) para diagnóstico da lesão. Medicação, repouso e crioterapia na fase aguda (87,5%) e medicação, repouso e fisioterapia durante o tratamento da lesão (56%) são as opções prevalentes. Os critérios de retorno ao esporte foram bastante subjetivos e díspares entre as opções apresentadas e a maioria dos entrevistados já usou alguma terapia adjuvante às tradicionais.

Conclusão: O número de lesões musculares tratadas anualmente é superior a 30, independentemente de se no setor público ou privado. Ocorre principalmente na junção miotendínea, nos membros inferiores e na fase excêntrica da contração muscular. O USG é o exame mais feito e a RM o considerado ideal. Para a maioria dos entrevistados o tratamento de escolha envolve repouso, medicação e fisioterapia. Além disso, 52% acreditam na eficiência do plasma rico em plaquetas (PRP) e 42% referem já tê-lo usado.

© 2014 Sociedade Brasileira de Ortopedia e Traumatologia. Publicado por Elsevier Editora Ltda. Todos os direitos reservados.

Introduction

Over recent decades, the number of people taking part in sports activities around the world has progressively increased. A large part of this increase has occurred because of the extensive dissemination by the media of the benefits to health that result from regularly practicing exercise. Exercise provides improvement of quality of life and reduction of the risk of having many diseases.¹⁻³

However, it is known that the benefits from practicing sports stand in contrast to the increase in the number of osteo-muscular injuries.⁴ Almost 10 million sports-related injuries occur every year in the United States.⁵ Most of them are not very severe, but they are painful and often incapacitating, since they take people away from their physical and professional activities.⁶

Muscle injuries are the commonest of these and account for 10-55% of all sports injuries. They consist mainly of bruises, sprains and lacerations.⁷ Injuries due to sprains generally affect superficial and two-joint muscles (rectus femoris, knee flexors and gastrocnemius) and they occur during the eccentric phase of contraction.⁸ The causes are multifactorial and there are some risk factors, such as age, previous muscle injuries in the same region, ethnicity, overloading, force imbalance and alteration of the capacity to stretch the muscle group in question.⁹

However, little has changed over recent decades regarding the way in which muscle injuries are understood and treated. The aim of the present study was to evaluate the

conceptualizations, diagnostic methods, treatment methods and perspectives of specialist physicians through applying a questionnaire among them, on muscle injuries in Brazil. From these results, it will be possible to delimit national trends on this little studied topic and guide subsequent new research in this field.

Methods

This was a descriptive study with application of a questionnaire to a sample formed mainly by sports physicians and orthopedists. This questionnaire was composed of 20 closed questions and was drawn up by the present authors in a simple and objective manner. It covered the main topic of the subject of muscle injuries ([Appendix 1](#)).

The questionnaire was applied to physicians who routinely treat muscle injuries who were attending the Second Brazilian Congress of Sports Arthroscopy and Traumatology (SBRATE), which took place in Fortaleza in 2013.

Thus, 168 questionnaires were filled out under guidance from one of the researchers for clarifications of any doubts that may have arisen.

From the data obtained through the questionnaires that were filled out, descriptive statistics were calculated on the variables involved, in order to characterize the sample.

The data were analyzed using the SPSS for Windows software, version 16.0, and the significance level was taken to be 5%.

Table 1 – Geographical distribution of the study participants.

	Number of physicians
North	9 (5%)
Northeast	44 (27%)
Center-West	18 (10%)
Southeast	79 (47%)
South	18 (10%)
Total	168

Results

There were 168 completed questionnaires, filled out by physicians from 20 states in all the five regions of Brazil (Table 1): 118 were orthopedists, 43 were orthopedists and sports physicians, five were sports physicians and two were from other specialties.

The mean length of time for which the professionals interviewed had been active in treating muscle injuries was 11 years. Most of the interviewees dealt with muscle injuries in both public and private services and saw more than 30 cases per year (Table 2).

Most of the injuries cited occurred in the lower limbs (97%): 30% in the quadriceps, 28% in the thigh adductors and 21% in the sural triceps. These injuries most commonly occurred during the eccentric phase of movement (in cases seen by 62% of the interviewees) and mostly affected the muscle-tendon junction (53%) and the muscle body (45%) (Table 3).

The examination most often performed by the physicians interviewed, in order to aid in the diagnosis, was ultrasound (39%), but the majority of them (84%) considered that magnetic resonance imaging was the best examination for making diagnoses (Table 4). Through the imaging examination, it was possible to classify the injuries using the method preferred by the majority of the interviewees (73%): the method that divides injuries into three grades according to the number of fibers injured. On the other hand, 24% of the interviewees preferred to classify injuries only with a description of the anatomical region injured. Moreover, 48% considered chronic muscle injuries to be those that had been presented for more than six weeks, 35% for more than three weeks and 15% for more than 3 months.

The treatment of choice in the acute phase of the injury for most of the interviewees was a combination of rest, cryotherapy and medication. Regarding the options for

Table 2 – Number of muscle injury cases treated within the public and private systems every year.

Muscle injury cases treated/year	Public service	Private service	Public and private
<10	4 (27%)	9 (13%)	11 (15%)
10-20	5 (33%)	13 (19%)	10 (13%)
20-30	2 (13%)	10 (15%)	25 (33%)
>30	4 (27%)	35 (52%)	29 (39%)
Total	15	67	75

Table 3 – Main characteristics of the muscle injuries: site affected and type of contraction at time of injury.

<i>Limb affected</i>	
Lower	97%
Upper	3%
<i>Muscle grouping</i>	
Quadriceps	30%
Thigh adductors	28%
Sural triceps	21%
Hamstrings	16%
Biceps brachialis	3%
Others	2%
<i>Type of contraction</i>	
Eccentric	62%
Concentric	30%
Isometric	3.50%
Not known	4.50%
<i>Region affected</i>	
Muscle-tendon junction	53%
Muscle body	45%
Bone avulsion	2%

Table 4 – Comparison between the examination most performed and the one considered ideal for diagnosing muscle injuries.

	Examination performed	Ideal examination
USG	65 (39%)	23 (14%)
MRI	62 (37%)	142 (84%)
USG + MRI	29 (17%)	0
Not used	12 (7%)	3 (2%)

USG, ultrasound; MRI, magnetic resonance imaging.

medications, the majority (35%) prescribed anti-inflammatory drugs alone, followed by analgesics (25%) and an association of anti-inflammatory drugs and analgesics (12%). For most of the interviews (56%), the treatment after the acute phase was composed of medication, rest and physiotherapy. In this case, the medication most prescribed was analgesics (Tables 5 and 6).

Table 5 – Main medications used for treating muscle injuries at the time of the injury (acute) and during the treatment period (post-injury).

Treatment	Acute	Post-injury
NSAID	59 (35%)	39 (23%)
AG	42 (25%)	74 (44%)
NSAID + AG	20 (12%)	7 (4%)
NSAID + AG + RX	20 (12%)	6 (3.5%)
NSAID + RX	18 (10.5%)	9 (5.5%)
AG + RX	5 (3%)	9 (5.5%)
RX	3 (2%)	15 (9%)
Other	1 (0.5%)	9 (5.5%)

NSAID, non-steroid anti-inflammatory drug; AG, analgesic; RX, muscle relaxant.

Table 6 – Therapeutic options for treating muscle injuries at the time of the injury and after the injury.

Treatment	Acute	Treatment	Post-injury
Medication + rest + cryo	147 (87.5%)	Medication + rest + physio	95 (56%)
Medication + rest	10 (6%)	Physio + rest	28 (17%)
Cryo + rest	7 (4%)	Physio	25 (15%)
Medication	0	Medication + rest	15 (9%)
Cryo	0	Medication	0
Other	4 (2.5%)	Other	5 (3%)

Cryo, cryotherapy; Physio, physiotherapy.

For injuries classified as grade I, the mean length of time away from sports activities was 13 days; grade II, 28 days; and grade III, 48 days. The main criteria used for determining the return to sport were comparison of muscle strength alone in the injured limb with the contralateral limb and combination evaluation of the pain scale and muscle strength in relation to the contralateral limb, along with the patient's own degree of confidence (Table 7).

The interviewees were also asked about other possible therapies cited in the literature that could be used for treating muscle injuries: 52% believed that treatment with platelet-rich plasma (PRP) was efficient, but only 42% had already used

Table 7 – Criteria used for the return to sport, for patients treated for muscle injury.

Criteria for return to sport	Number
FM contralateral	24 (14%)
Pain + contralateral MS + confidence	23 (13.5%)
Pain + contralateral MS	22 (13%)
All options	19 (11%)
Pain	16 (9.5%)
Other options	14 (8.5%)
Confidence	13 (7.5%)
Pain + confidence	12 (7%)
Imaging examination	5 (3%)
Pain + imaging examination	5 (3%)
Contralateral MS + confidence	5 (3%)
Pain + contralateral MS + imaging examination	3 (2%)
MS + imaging examination + confidence	2 (1%)
MS + imaging examination	1 (0.5%)
Pain + imaging examination + confidence	1 (0.5%)
Pain + MS + circumference of injured limb	1 (0.5%)
Pain + confidence + circumference of injured limb	1 (0.5%)
MS + imaging examination + circumference of injured limb	1 (0.5%)
Circumference of injured limb	0

Contralateral MS refers to comparison of muscle strength between the injured and uninjured sides; pain is evaluated by means of a visual analog scale; confidence is a subjective measurement; imaging examination relates to follow-up of the evolution of the injury; circumference of the injured limb refers to evolution comprising hypotrophy caused by the injury.

Table 8 – Interviewees' opinions regarding the efficiency of new therapies presented in the literature, for treating muscle injuries, and whether they had had the opportunity to use the respective therapeutic options.

Therapy	Efficiency	Used
PRP	88 (52%)	70 (42%)
Shockwaves	45 (27%)	45 (27%)
Gene therapy	11 (6.5%)	0
Local infiltration	7 (4%)	36 (21%)
Others	20 (12%)	18 (11%)
No opinion	24 (14%)	40 (24%)

PRP, platelet-rich plasma.

this therapeutic method, while 14% did not believe in any of the methods presented and 24% had never used any of these therapeutic methods (Table 8).

Discussion

Muscle injury is the commonest type of musculoskeletal injury. It may represent up to 50% of all orthopedic complaints. In most cases, the patient is capable of returning to activities at the same level as before the injury, without functional deficits.^{10,11} Nonetheless, little is known about these injuries. There is no consensus on the best way of defining their severity, the most appropriate treatment and the most efficient form of rehabilitation.

The present study evaluated the main topics involved in muscle injuries and investigated them among a population of highly specialized physicians who were accustomed to dealing with this pathological condition.

These questions were put to 168 sports physicians and/or orthopedists from all regions of Brazil whose mean level of experience of treating muscle injuries was 11 years.

When the number of muscle injuries treated per year was evaluated, it was seen that, independent of the subspecialization of orthopedist or sports physician, these were the injuries most frequently treated at the places where the majority of the interviewees attended patients. Independent of whether attendance was within the public or private system, the mean number of cases of injuries exceeded 30 per year. The great majority of the physicians reported that the commonest injuries were in the lower limbs, which is in line with the sports practices that are most popular in our setting, i.e. soccer and athletics. The result was that greater numbers of injuries occurred in the muscles groupings involved, for

example, in kicking movements: quadriceps, thigh adductors and sural triceps.

In the literature, muscle injuries have been correlated with eccentric contraction.¹²⁻¹⁵ 62% of the interviewees also took the view that the majority of the injuries occurred during this phase of the contraction, which should serve as information for correct physical preparation and injury prevention among athletes practicing a variety of physical activities.

Although many classifications have been described with the aim of better understanding of the types of muscle injury, we believe that there is still no consensus about the best way of differentiating between them.¹⁶ The difficulty in making samples homogenous makes comparison between different injuries very complex. Classifications may relate to anatomy, the region in which the muscle fibers are affected or the time elapsed since the injury, among many others. In the present study, the majority of the participants chose to define the type of injury according to the number of fibers injured and they divided these injuries into three types: grades I, II and III. However, even though this classification depends on an imaging examination, it is still very subjective and results from the opinion of the physician who makes the assessment. Even so, this is the classification that best led the professionals to the type of treatment and the length of time for which the athlete will be away from his sport. It was seen that the higher the grade of the injury was, the longer the time for which the study participants chose to keep the athletes from their activities was. In discussing the time required for defining an injury as acute or chronic, there was also a very wide range of opinions. In the literature, there has been little scientifically base description of what constitutes a chronic injury.¹⁶ In the present study, 48% believed that these are injuries that occurred more than six weeks ago, 35% more than three weeks ago and 15% more than three months ago.

In relation to the diagnostic method, there was concordance with the literature regarding the notion that magnetic resonance imaging would be the ideal examination,¹⁷ although the majority of the interviewees used ultrasound. This can be explained by the difference in costs between the examinations, although this may no longer be the rule in other countries, where the costs of magnetic resonance imaging are not as high as it is in Brazil.

The treatment for muscle injuries is without doubt the most controversial item. Although the same treatment has been used for more than 40 years, some therapies have been described and have started to be used in our setting, even though in some situations there has been little basis for this in the literature. In the acute phase, the great majority of the interviewees mainly used analgesic and anti-inflammatory medications, in association with rest and cryotherapy.

The subsequent treatment, which in most cases is guided by the type of injury, was composed of physiotherapy, rest and medication, according to 56% of the interviewees. This has been the conventional trio of treatments for muscle injuries for many years. Over this time period, much has been said about adjuvant therapies that might accelerate muscle healing and provide an earlier return to sport. We asked the participants whether they considered that treatments with PRP, shockwaves, local infiltration and gene therapy were efficient. Most of them believed that PRP treatment would be efficient, followed by shockwaves, gene therapy and infiltration. However, when asked whether they were using these therapies, smaller numbers of participants affirmed this: 42% had already used PRP, 27% shockwaves and 21% infiltration. None of them mentioned using gene therapy.

For the return to sports practice, the main criteria used by the participants were comparison of muscle strength with the contralateral side, comparison of the combined results from the visual analog pain scale and muscle strength with the contralateral side and the patient's confidence. The great challenge in treating muscle injuries probably relates to the exact time at which injured patients can return to their sports activities at a high performance level. Today, many criteria are used to measure this capacity to return, but in most cases these methods are still subjective, with little scientific evidence.

Although this was purely a descriptive study, with a low level of evidence, it has great importance in that it analyzed the way in which specialists deal with injuries that are so common yet so little studied with regard to the main aspects of this pathological condition.

Conclusion

The number of muscle injury cases treated every year was greater than 30, independent of whether this was in the public or private sector. The injuries occurred mainly at the muscle-tendon junction, in the lower limbs and during the eccentric phase of muscle contraction. Ultrasound was the examination most used, while magnetic resonance imaging was considered to be ideal. The preferred treatment involved rest, medication and physiotherapy, for the majority of the interviewees. Moreover, 52% of the physicians believed that PRP was efficient and 42% said that they had used it.

Conflicts of interest

The authors declare no conflicts of interest.

Appendix 1. Questionnaire applied during a congress, to ask professionals within this field about their management of muscle injuries



Questionário Tratamento de Lesões Musculares

Cidade/Estado: _____

* significa mais de uma alternativa pode ser preenchida



1- Anos Experiência Tratamento de Lesão Muscular: _____ anos

2- Especialidade Médica

- Ortopedista
 Médico do Esporte
 Outro. Qual _____

3- Quantas lesões musculares você trata por ano?

Numero por ano	Serviço Público	Privado/Particular
< 10		
10-20		
20-30		
>30		

4- Em sua prática, qual região a lesão é mais comumente vista:

- Membros Superiores
 Membros Inferiores

5- Em sua prática, qual o grupamento muscular mais comumente lesado:

- Quadríceps
 Tríceps Sural
 Adutores da Coxa
 Peitoral
 Bíceps Braquial
 Outro. Qual _____

6- Em que tipo de contração você considera mais comum a lesão muscular:

- Concêntrico
 Excêntrico
 Isométrico

7- Em sua prática, qual o tipo de lesão mais vista:

- Avulsão Óssea
 Junção Miotendínea
 Corpo muscular

8- Em sua prática, qual a classificação mais utilizada:

- Anatômica
 Quantidade de fibras lesadas (3 graus)
 Temporal
 Outra. Qual _____

9- O que você considera lesão muscular crônica:

- > 1 semana
 > 3 semanas
 > 6 semanas
 > 3 meses

10- Qual exame de imagem você costuma realizar para diagnosticar a lesão muscular:*

- Não utilizo exame de imagem
 Ultrassom
 Ressonância Magnética

11- Qual exame de imagem você considera ideal para diagnosticar a lesão muscular:

- Não utilizo exame de imagem
 Ultrassom
 Ressonância Magnética

12. Como você trata uma lesão muscular no momento da lesão:

- Medicação
 Medicação + Repouso
 Medicação + Repouso + Crioterapia
 Crioterapia + Repouso
 Crioterapia
 Outro. Qual _____

13. Se você utiliza gelo para o tratamento da lesão no momento da lesão, costuma realizar com o membro do músculo lesado em flexão ou extensão?

- Flexão
 Extensão
 Não me atendo a este detalhe

14. Qual medicação você utiliza para o tratamento da lesão muscular no momento da lesão:*

- Analgésico
 Anti Inflamatório
 Relaxante Muscular
 Outro. Qual _____

15. Como você trata uma lesão muscular nos dias subsequentes a lesão:

- Medicação
 Medicação + Repouso
 Medicação + Repouso + Fisioterapia
 Fisioterapia + Repouso
 Fisioterapia
 Outro. Qual _____

16. Qual medicação você utiliza para o tratamento da lesão muscular nos dias subsequentes da lesão:*

- Analgésico
 Anti Inflamatório

- Relaxante Muscular
 Outro. Qual _____

17. Se você afasta o paciente de sua prática esportiva, quantos dias você julga necessário de repouso de acordo com a classificação que considera o número de fibras lesadas:*

- Grau I: _____ dias
 Grau II: _____ dias
 Grau III: _____ dias

18. Qual das seguintes terapias para a lesão muscular você acredita que seja eficiente:*

- Terapia por Onda de Choque
 PRP
 Infiltração Local
 Terapia Gênica
 Outra. Qual _____

19. Qual das seguintes terapias para a lesão muscular você já utilizou:*

- Terapia por Onda de Choque
 PRP
 Infiltração Local
 Terapia Gênica
 Outra. Qual _____

20. Quais critérios você utiliza para o paciente retornar à prática esportiva:*

- Escala de dor
 Força muscular comparada ao lado contralateral
 Circunferência do membro lesado
 Evolução da lesão no exame de imagem
 Paciente se sentir confiante para a prática
 Outra. Qual _____

REFERENCES

- Silva OC. A qualidade de vida ligada à prática regular de atividades físicas. *EFDeportes*. 2010;150.
- Programa Nacional de Promoção da Atividade Física Agita Brasil. Atividade física e sua contribuição para a qualidade de vida. *Rev Saúde Públ*. 2002;36(2):254-6.
- Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Off J Am Coll Sports Med*. 2007;1423-34.
- Maffuli N, Longo UG, Gougoulis N, Caine D, Denaro V. Sport injuries: a review of outcomes. *Br Med Bull*. 2011;97:47-80.
- Nicholl JP, Coleman P, Williams BT. The epidemiology of sports and exercise related injury in the United Kingdom. *Br J Sports Med*. 1995;29(4):232-8.
- Galer BS, Rowbotham M, Perander J, Devers A, Friedman E. Topical diclofenac patch relieves minor sports injury pain: results of a multicenter controlled clinical trial. *J Pain Symp Manage*. 2000;19(4):287-94.
- Järvinen TA, Järvinen TL, Kääriäinen M, Aärimaa V, Vaittinen S, Kalimo H, et al. Muscle injuries: optimizing recovery. *Best Pract Res Clin Rheumatol*. 2007;21(2):317-31.
- Lindqvist KS, Timpka T, Bjurulf P. Injuries during leisure physical activity in a Swedish municipality. *Scand J Soc Med*. 1996;24(4):282-92.
- Opar DA, Williams MD, Shield AJ. Hamstring strain injuries: factors that lead to injury and re-injury. *Sports Med*. 2012;42(3):209-26.
- Fernandes TL, Pedrinelli A, Hernandez AJ. Lesão muscular – Fisiopatologia, diagnóstico, tratamento e apresentação clínica. *Rev Bras Ortop*. 2011;46(3):247-55.
- Järvinen TAH, Järvinen TLN, Kääriäinen M, Kalimo H, Järvinen M. Muscle injuries. Biology and treatment. *Am J Sports Med*. 2005;33(5):745-64.
- Choi SJ, Lim JY, Nibaldi EG, Phillips EM, Frontera WR, Fielding RA, et al. Eccentric contraction-induced injury to type I, IIa, and IIa/IIx muscle fibers of elderly adults. *Age (Dordr)*. 2012;34(1):215-26.

13. Lieber RL, Fridén J. Mechanisms of muscle injury after eccentric contraction. *J Sci Med Sport*. 1999;2(3): 253-65.
14. Pull MR, Ranson C. Eccentric muscle actions: implications for injury prevention and rehabilitation. *Phys Ther Sport*. 2007;8(s1):88-97.
15. Allen DG. Eccentric muscle damage: mechanisms of early reduction of force. *Acta Phys Scand*. 2001;171(s1): 311-9.
16. Mueller-Wohlfahrt HW, Haensel L, Mithoefer K, Ekstrand J, English B, McNally S, et al. Terminology and classification of muscle injuries in sport: the Munich consensus statement. *Br J Sports Med*. 2013;47(6):342-50.
17. Dias EP, Marchiori E, Coutinho Junior AC, Domingues RC, Domingues RC. Avaliação por ressonância magnética das injúrias musculares traumáticas. *Radiol Bras*. 2001;34(6):327-31.