Bulletin of the *Transilvania* University of Braşov
Series IX: Sciences of Human Kinetics • Vol. 15(64) No. 2 – 2022
https://doi.org/10.31926/but.shk.2022.15.64.2.2

MUSCLE INJURY IN SPORTS ACTIVITY – ETIOLOGY, CLASSIFICATION AND TREATMENT

B.A. ANTOHE[1] M. RAȚĂ[1] B.C. RAȚĂ[1] G. RAȚĂ[1]

Abstract: *Muscle lesions are among the most common injuries encountered in performance sports. Despite their high incidence, their diagnosis, classification and treatment are constantly being debated. Most of the time, the severity of the injury indicates the recovery strategy (conservative, physical therapy, surgical etc). Currently, due to advances in medical, pharmacological, and physical therapy, the treatment of muscle injuries can be greatly improved. Incomplete or incorrect recovery from a muscle injury can have a series of negative effects (financial or sport performance), which can affect the long-term career of athletes. Considering the incidence and costs that an injury can generate, in this paper, we set out to identify and present the latest approaches, used by specialists in the field, to facilitate the fastest recovery of athletes.*

Key words: *muscle*, *injury, lesion, sports, rehabilitation.*

1. Introduction

The human body has three types of muscle tissue: smooth, cardiac and skeletal. Visceral muscle and cardiac muscle fall into the category of involuntary muscles, while striated muscle is part of the category of voluntary muscles. This paper discusses lesions of striated muscle tissue.

Due to the very large number of striated muscles (approximately 430, whose weight represents 30% of the body weight) as well as the variations in shape and structure, the chances of muscle damage are very high [21].

The main role of striated muscles is the biomechanical one. By their insertion on the bones, the striated muscles produce movement. Considering this aspect, and knowing the activity of performance athletes, characterized by fast movements, strong contractions, frequent changes in the type of muscle contraction, we can easily understand the causes that lead to muscle injuries.

By definition, muscle injuries represent a heterogeneous group of traumas (ruptures, strains and contractures), which can occur directly or indirectly and are characterized by a total or partial loss of muscle function [18].

Epidemiological research in performance sport reports between 10

[1] "*Vasile Alecsandri*" University of Bacău, Faculty of Movement, Sport and Health Sciences. 157 Calea Mărăşeşti, Bacau, Romania

and 55% of injuries as muscle lesions [12]. The likelihood of developing a muscle injury is 7 times higher during playing than during training [13], with a major predisposition to injury in the musculoskeletal junction [3]. These values vary according to the sport played, as follows: football 30%, rugby 11%, track and field 16%, and basketball 18%. In the sports mentioned, the most affected muscle groups are: hamstrings (29%) [6], quadriceps and adductors [5]. In addition, the chances of reinjured are between 12 and 33% for hamstrings [7] and between 7 and 22% for quadriceps [8], in the first 30 days after resuming sports activity.

2. Material and methods

The research methods used during the research were as follows: the theoretical documentation method and the method of data processing and graphic representation.

To identify the articles and books that we studied to make this paper, we used the following databases: Google Academic, ResearchGate and PubMed.

Within the databases, in the search section, we entered the following keywords: muscle, injury, lesion, sports and rehabilitation. Both experimental articles and reviews of specialized literature were selected and cited. Articles that were published earlier than 2010 were excluded from the research.

3. Discussions

3.1. Etiology of muscle lesions

Understanding the mechanism of muscle lesions is very important for the clinician, as it is the basis for formulating the first hypotheses about the severity of the injury, but also for the coach and teacher, as they can perform the training and avoid the possibility of injury.

According to the mechanism of production, muscle lesions are classified into:

- ***extrinsic***, caused by a direct trauma and these can be in the form of:
  - contusions [10], which can be:
  - small with minor functional impairment;
  - medium with medium functional impairment;
  - large with major functional impairment.
  - lacerations caused by a direct trauma, such as a blunt object. They occur rarely, in about 8% of cases [10].
- ***intrinsic***, not involving a direct trauma, but a strong contraction of the muscle (eccentric) or a stretch that exceeds the limits of muscle elasticity. Research has shown that excessive stretching of sarcomeres leads to muscle lesions [20].

3.2. Classification of muscle lesions

In recent years, the literature has proposed several classifications of muscle lesions. In Table 1 we present the latest approaches to muscle lesion classification.

Table 1

Muscle lesion classification [5], [6], [16]

Classification				Definition and causes	Clinical signs
Direct	*Contusion*		-	▪ Direct muscle trauma caused by an external force. ▪ Symptoms: pain and inflammation. ▪ No major structural changes reported.	▪ Pain at the time of and after the injury. ▪ Limitations of joint mobility and partial limitation of muscle function.
	Laceration		-	▪ It is caused by an external blunt force, which causes lesions to the tegument and the muscle level ▪ If the laceration is very large, surgery is needed to suture the lesion.	▪ The signs are visible to the naked eye. ▪ Pain and major or total functional impotence.
Indirect	*Functional*	Type 1 muscle disorders caused by overstrain	1A Functional disorders induced by muscle fatigue	▪ Increased muscle tone and muscle shortening	▪ Diffuse tolerable pain. ▪ Continued physical activity may cause pain. ▪ Stretching relieves symptoms
			1B Delayed-onset muscle soreness	▪ Generalized muscle pain caused by strong muscle contractions, especially eccentric ones, which produce microscopic lesions to the muscular system.	▪ The muscle gets inflamed and becomes painful, both at rest and in movement. ▪ The muscle is stiff and joint range of motion is partially limited.
		Type 2 muscle disorders of neuromuscular origin	2A Spinal muscle disorders	▪ Increased muscle tone due to functional/structural disorders in the spine.	▪ Muscle stiffness, which is intensified during exercise. ▪ Rest relieves symptoms.
			2B Eye disorders caused by the central nervous system	▪ Increased muscle tone due to altered neuromotor control (e.g. mutual inhibition or functional changes in the neuromuscular spindle)	▪ Areas of increased tone can be identified in the muscular system. ▪ The muscle is sore on palpation. ▪ Stretching relieves the symptoms.
	Structural	Type 3 partial muscle lesions	3A Minor muscle injury	▪ Involves a small number of muscle fibres (one fascicle or less than 5% of the entire muscle).	▪ Acute pain, accompanied by increased muscle tone and local contractures. ▪ Functional limitations are minor.

Classification				Definition and causes	Clinical signs
			3B Moderate muscle injury	▪ Involves several muscle fascicles. During trauma, a sound may be heard.	▪ The pain is very strong and well localized. ▪ Muscle strength is low and functional impairment is major. ▪ Stretching enhances the pain.
		Type 4 complete muscle lesions	Full muscle injury or tendon avulsion	▪ Muscle end pullback occurs.	▪ The pain is very strong and well localized. ▪ There are palpable discontinuities in the muscular system. ▪ We can palpate a considerable hematoma. ▪ Functional impairment is total.

3.3. Treatment of muscle injuries

Recovery from muscle lesions follows the three stages of tissue repair [15].

- *degeneration or inflammatory phase* is characterized by rupture and necrosis of myofibrils, hematoma formation and inflammation of the muscle. It lasts between 24 and 72 hours;
- *regeneration phase* is characterized by phagocytosis of the injured tissue and regeneration of myofibrils. It lasts between 4 and 21 days;
- *remodelling phase* is characterized by the formation of scar tissue. Myocytes mature and the functional capacities of the muscle are restored. This phase begins 21 days after the injury and can last up to a year, depending on the severity of the injury.

The recovery process of muscle lesions can be improved by the use of orthobiological treatments. It involves the use of prolotherapy, platelet rich plasma (PRP), platelet rich fibrin-matrix (PRFM), mesenchymal stromal cells (MSCs) and amniotic-based products [19]. All these treatment methods have proven their efficiency by their potential to accelerate tissue regeneration [22].

3.3.1. Possible complications during recovery

During the recovery of a muscle, a series of complications may occur. The most common are as follows: deep vein thrombosis, ossifying myositis, post-traumatic fibrosis, infection, rhabdomyolysis, and acute compartment syndrome, muscle herniation, etc [2].

3.3.2. Literature recommendations for the treatment of muscle lesions

In the literature, specialists recommend treatments for muscle lesions according to the three stages of recovery mentioned in subchapter 3.3. Treatment recommendations are given in Table 2.

Table 2

Literature recommendations for muscle lesion recovery according to the stage of recovery [4], [9], [11], [17], [25]

Recovery phase	Recommendations	Instruments
Inflammatory	▪ It is recommended to use the acronym POLICE (P = protection, OL = optimal loading, I = ice, C = compression and E = elevation), which unlike standard protocols for reducing inflammation, also includes the optimal loading term. The application of mechanical loading during the inflammatory phase represents a shift in the recovery paradigm, as early tissue mobilization limits the appearance of scar adhesions and facilitates faster tissue recovery. ▪ The use of NSAIDs in the first 48 hours after injury is not recommended as they may have a negative effect on healing time and muscle fibre strength after recovery.	▪ Cryotherapy; ▪ Kinesiotaping; ▪ NSAIDs (if absolutely necessary); ▪ Elements of physiotherapy (electrotherapy, magnetic therapy, ultrasound, etc.); ▪ Postural therapy; ▪ Partial immobilisation; ▪ Passive mobilisation; ▪ Compression bandages.
Degenerative/ proliferative	▪ Orthobiological injections (PRP, PRFM) are recommended at this stage, starting on day three after the trauma. Orthobiological treatment can also be applied 7 or 14 days after the injury, depending on the specifics of the condition. ▪ Another important objective is to obtain an elastic (structurally) and strong (functionally - transmission of contraction forces) scar. We increase the mechanical load on the muscle and partially prepare for readaptation to stress. ▪ During muscle contractions and stretching, it is recommended that the intensity of pain does not exceed 3 on a scale of 1 to 10.	▪ Therapeutic massage; ▪ Stretching; ▪ Static and dynamic exercises that require contraction of the affected muscle in the form of synergistic muscle; ▪ Progressive isometric and isotonic muscle contractions performed with the affected muscle, depending on the subject's functional capabilities; ▪ Eccentric muscle contractions, performed 14 days after the trauma.
Remodelling (28 +days)	Gradual return at sport activities	All the means mentioned above, at a progressively increasing intensity, adapted to the stage of recovery and the severity of the lesion

3.3.4. *Interdisciplinary team and returning at sports activity*

Today, in performance sport, interdisciplinary has become the quality standard for achieving the best results. The interdisciplinary team includes the coach, physical therapist, physiotherapist, sports and nutrition physician, psychologist, etc. Sports activity can only be resumed when the athlete has received

the consent of the interdisciplinary team in charge of his/her recovery [24].

The Iowa State University protocol [15] proposes the following steps to be followed before resuming sports activities:

- initial ultrasound evaluation and classification of the injury, preferably within the first 24-48h;
- if there is a hematoma greater than 3-5 ml, it is recommended to have it aspirated;
- start the physiotherapy recovery programme as soon as possible;
- after reaching a functional level of 80% of initial functional capacity, reassess the lesion ultrasonographically to determine the degree of recovery;
- if the results are positive, the athlete can gradually increase the level of effort to a functional level of 90%;
- before resuming sports activity, the subject must complete all functional and field tests specific to the sport practiced in order to receive a favourable opinion from the rehabilitation team.

4. Conclusions

Although they are among the most common conditions in performance sport, muscle lesions still challenge the rehabilitation specialists.

Taking into account the difficulties faced by the interdisciplinary team in the recovery of these conditions, we hope that the information presented in this paper will provide a system of guidelines for recovery, according to muscle lesion classification, stages of recovery and the most important means with which to intervene.

5. Proposals

Following the ideas presented, we suggest a series of recommendations, which can be applied immediately in the practice of specialists and whose results would be visible in a very short time:

- use of the proposed muscle injury classification system, as it provides objectivity in diagnosis, both anatomically and functionally;
- following the physiological steps of muscle tissue healing, without skipping any stage, as there is a high chance of recurrence;
- avoiding the use of NSAIDs in the first stage of the injury, as this can delay muscle regeneration;
- introducing early mobilization into the recovery programme, which has a beneficial effect on scar tissue and the functional capacities of the muscle;
- use of eccentric muscle contractions 14 days after injury to treat and prevent a new lesion.

References

1. Ahmad, C.S., Redler, L.H., Ciccotti M.G., et al.: *Evaluation and management of hamstring injuries*. In: Am. J. Sports Med, 2013, Vol. 41(12), p. 2933–2947.
2. Alessandrino, F., Balconi, G.: *Complications of muscle injuries.* In: Journal of ultrasound, 2013, Vol. 16(4), p. 215–222. https://doi.org/10.1007/s40477-013-0010-4.
3. Askling, C.M., Tengvar, M., Saartok, T., et al.: *Acute first-time hamstring strains during high-speed running: a longitudinal study including clinical and magnetic resonance imaging findings.* In: The American Journal of

Sports Medicine, 2007, Vol. 35(2), p. 197–206. https://doi.org/ 10.1177/0363546506294679.

4. Bleakley, C. M., Glasgow, P., MacAuley, D.C.: *PRICE needs updating, should we call the POLICE?* In: Br. J. Sports Med, 2012, Vol. 46, p. 220–221. doi:10.1136/bjsports-2011-090297.
5. Canata, G., d'Hooghe, P., Hunt, K.: *Muscle and Tendon Injuries. Evaluation and Management.* Berlin, Springer, 2017, p. 96-99.
6. Chan, O., Del Buono, A., Best, T. M., et al.: *Acute muscle strain injuries: a proposed new classification system.* In: Knee Surgery, Sports Traumatology, Arthroscopy, 2012, Vol. 20(11), p. 2356–2362. doi:10.1007/s00167-012-2118-z.
7. Dalton, S.L., Kerr, Z.Y., Dompier, T.P.: *Epidemiology of hamstring strains in 25 NCAA sports in the 2009–2010 to 2013–2014 academic years*. In: Am. J. Sports Med*,* 2015, Vol. 43, p. 2671–2679.
8. Eckard, T.G., Kerr, Z.Y., Padua, D.A., et al.: *Epidemiology of quadriceps strains in National Collegiate Athletic Association athletes, 2009–2010 through 2014–2015.* J. Athl. Train*., 2017, Vol 52, p.474–481.*
9. Fernandez-Jaén, T.F., Rey, G.Á., Cuesta, J.A., et al.: *Spanish Consensus Statement*. In: Orthopaedic Journal of Sports Medicine, 2015, Vol. 3(12), doi:10.1177/2325967115622434.
10. Grassi, A., Quaglia, A., CanG. L., et al.: *An update on the grading of muscle injuries: a narrative review from clinical to comprehensive systems.* In: Joints, 2016, Vol. 4(1), p. 39–46. https://doi.org/10.11138/jts/ 2016. .4.1.039.
11. Hall, M.: *Return to Play After Thigh Muscle Injury.* In: Current Sports Medicine Reports. 2018, Vol. 17(9), p.296-301, doi: 10.1249/ jsr. 0000000000000516.
12. Han, O., Del Buono, A., Best, T. M., et al.: *Acute muscle strain injuries: a proposed new classification system. Knee surgery, sports traumatology, arthroscopy: official.* In: Journal of the ESSKA, 2012, Vol. 20(11), p. 2356–2362. https://doi.org/ 10.1007/s00167-012-2118-z.
13. Keller, K., Engelhardt, M.: *Strength and muscle mass loss with aging process. Age and strength loss.* In: Muscles, ligaments and tendons journal, 2014, Vol. 3(4), p. 346–350.
14. Laumonier, T., Menetrey, J.: *Muscle injuries and strategies for improving their repair.* In: Journal of experimental orthopaedics, 2016, Vol. 3(1), p. 15. https://doi.org/10.1186/ s40634-016-0051-7.
15. Liao, CH., Lin, LP., Yu, TY. Et al.: *Ibuprofen inhibited migration of skeletal muscle cells in association with down regulation of p130cas and CrkII expressions*. In: Skeletal Muscle, 2019, Vol. 9, p. 23. https://doi.org/10.1186/s13395-019-0208-z.
16. Lieber, R. L., Fridén, J.: *Mechanisms of muscle injury after eccentric contraction.* In: Journal of Science and Medicine in Sport, 1999, Vol. 2(3), p. 253–265. doi: 10.1016/s1440-2440 (99)80177-7.
17. Mackey, A., Mikkelsen, U.R., Magnusson, S., et al.: *Rehabilitation of muscle after injury – the role of anti-infl ammatory drugs*. In: Scand J. Med. Sci. Sports, 2012, Vol. 22(4), p. 8–14.
18. Mueller-Wohlfahrt, W., Haensel, L.,

Mithoefer, K., et al.: *Terminology and classification of muscle injuries in sport: The Munich consensus statement.* In: British Journal of Sports Medicine. 2012, Vol. 47(6), p.342–350. doi:10.1136/ bjsports-2012-091448.

19. Musiał-Wysocka, A., Kot, M., Majka, M.: *The Pros and Cons of Mesenchymal Stem Cell-Based Therapies*. In: Cell transplantation, 2019, Vol. 28(7), p. 801–812. https://doi.org/10.1177/0963689719837897.
20. Oliva, F., Via, A. G., Kiritsi, O., et al: *Surgical repair of muscle laceration: biomechanical properties at 6 years follow-up.* In: Muscles, ligaments and tendons journal, 2014, Vol. 3(4), p. 313–317.
21. Palastanga, N., Field, D., Soames, R. *Anatomy and human movement – structure and function*. Elsevier, 2006, p. 14.
22. Rossi, L.A., Molina Rómoli, A.R., Bertona Altieri, B.A., et al.: *Does platelet-rich plasma decrease time to return to sports in acute muscle tear? A randomized controlled trial.* In: Knee Surgery, Sports Traumatology, Arthroscopy, 2016, Vol. 25(10), p. 3319–3325. doi:10.1007/s00167-016-4129.
23. Sailly, M.: *Muscle Contusions: Extrinsic Muscle Lesions.* Muscle Injuries in Sport Athletes, 2017, p. 187–200. doi:10.1007/978-3-319-43344-8_11.
24. Setayesh, K., Villarreal, A., Gottschalk, A., et al.: *Treatment of Muscle Injuries with Platelet-Rich Plasma: a Review of the Literature.* In: Current Reviews in Musculoskeletal Medicine, 2018, doi:10.1007/s12178-018-9526-8.
25. Wong, S., Ning, A., Lee, C., et al.: *Return to sport after muscle injury*. In: Current reviews in musculoskeletal medicine, 2015, Vol. 8(2), p. 168–175. https://doi.org/ 10.1007/s12178-015-9262-2