51 Evaluation of Muscle Injuries

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51.1 Introduction

Muscle injuries are among the most frequent injuries in sport, accounting for up to one-third of all sports-related injuries; they are responsible for 25% of days of absence away from training and competition [1]. Despite their considerable impact, there is still a lack of high-quality studies evaluating their specific control [2]. This entity is common, often occurring during sports practice, affecting the athlete's functional capacity and ability to continue [3].

Athlete's return to competition and injury prevention are the physician's main goal. The clinical evaluation and imaging information is crucial to dictate prognosis [3]. Since the 1980s, availability of ultrasound (US) and magnetic resonance imaging (MRI) has been permitting direct visualization of muscle tears, resulting in appreciable tools to confirm and address the extent of muscle injuries helping to lead the management [2].

Despite the recognition of many risk factors and prevention protocols, muscle injuries have been increasing over the last 12 years. Therefore, it is necessary to enhance our knowledge based on clinical experiences and supported by scientific evidence about this issue [4].

51.2 Epidemiology

Muscle injuries are frequent in high-demand sports, accounting for 10–55% of all acute sports injuries [5]. In view of all damaging consequences, this current scenario causes a necessity for better comprehension of muscle tears and specially their prevention has turned a considerable challenge to the sports medicine centers all over the world [4].

Regarding professional soccer players, muscle injuries represent 31% of all injuries and are responsible for 25% of days of absence from training and competition [5]. The majority of muscle injuries (92%) affect the lower extremity involving the four major muscle groups: hamstrings, adductors, quadriceps, and calves, with the hamstring injuries being the most common single type, representing 12–37% of all [2, 4]. In

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addition, the incidence risk of muscle tears in this population is six times higher during match play compared to training. Age represents another attribute involved with muscle injuries; the increase occurs in players aged over 30, emphasizing the sural triceps [4, 5].

In other modalities, the incidence of muscle injuries is variable: 16% in running sports, 11% in rugby, and 18% in basketball. In all these sports, the main affected muscles are the hamstrings, quadriceps, and adductors [5].

51.3 Etiology

The main function of skeletal muscle is to perform as the "motor" driving the muscle-tendon-bone unit, producing movement and locomotion. This unit is an extraordinarily organized complex of tissues consisting of the following: the muscle; the myotendinous junction, where muscle fibers interdigitate with collagen, allowing force to be transferred from the muscle to the tendon; the tendon, which may be at the ends of and/or within the muscle; the enthesis, where the tendon attaches to the bone; and the bone [3].

The injury therefore depends on the impact intensity, state of contraction of the muscle, traumatic moment, and muscle injured. Muscle injuries usually occur in the eccentric phase of the muscle contraction after an indirect insult, more common in noncontact sports, and after direct trauma, as in contact sports.

Trauma mechanisms can be divided into direct and indirect forms. The former indicates that the muscle is damaged directly by an externally applied force, such as contusion or penetration. In contrast, the indirect form refers to muscle trauma that occurs secondary to a nonphysiologically or abrupt elongation. Whereas the direct type of injury typically results in hemorrhage, hematoma, and/or laceration of the target muscle, the indirect type commonly results in muscle strains or tears. The direct injury mostly occurs where the maximal external force is exerted, whereas the indirect type frequently takes place across the myotendinous junction of the affected muscles [5].

Direct muscle injuries are a commonplace in sports that involve frequent body contact, such as rugby, basketball, and soccer. However, indirect muscle injuries more often occur during activities in which the contracted muscles undergo excessive traction [6]. Muscle strain is the most common presentation of an indirect-type injury resulting from extravagant stretching of a shortened muscle.

The most prevalent location for muscle strain is the myotendinous junction, where the distal tendons are interwoven with the muscle fibers to relay contraction forces. The myotendinous junction (MTJ) reveals less capacity for energy absorption than muscle and tendon. In animal models, the average tension leading to MTJ failure is only 20% greater than the maximum isometric tension normally produced during activity [3, 6].

The MTJ is situated at a variable distance from the bone, and the tendinous portion located between the bone and the MTJ is named as the "free tendon." Therefore, muscles with short free tendons, such as the deltoid and gluteus maximus, appear to insert virtually directly on the bone, whereas muscles such as the biceps brachii, rectus femoris, and plantaris have free tendons varying in length [3].

51.4 Physical Exam

Physical examination routine includes the inspection and palpation of the injured area and also function tests of the suspicious injured muscles both with and without resistance. The main objectives are to determine the precise location (region, muscle(s), tendon, or fascia involvement) and presume the severity of the injury. The diagnostic accuracy of the tests is quite variable; therefore, a bilateral comparison should always be performed to help the exam accuracy (Table 51.1) [4].

In the past, the earliest efforts to grade the severity of muscle injuries were based on the symptoms and signs present on physical exam and this evaluation composed the basis for grading a given injury as "mild," "moderate," or "severe" [7].

Table 51.1 Physical examination assessment for muscle injuries [4]

Inspection	Ecchymosis or deformities on the muscle belly profile (Fig. 51.1)	
	Important issues:	
	Swelling?	■ This usually determines the severity of the injury
	Hematoma?	■ This suggests a structural injury/tear
	Retraction of muscles?	■ This suggests a severe injury/tear
	Changes to contours of muscle? Hint: *Hematomas, muscle retraction, and changes to the contours of a muscle are only seen in structural injuries*	■ This suggests a severe injury/tear
Palpation	Identify the specific region injured through pain provocation and presence or absence of a palpable defect in the musculotendinous junction (Fig. 51.2)	
	Important issues:	
	Localized or larger area?	■ This helps to identify injury location: Localized pain is more likely in a structural injury. Larger pain area tends toward functional injury
	Muscle tone?	■ Helps to determine injury type
	Edema?	■ Helps to identify injury location and injury type
	Pain/relief on careful stretching?	■ Pain on stretching suggests a tear
	Palpable defect Note: Muscle tension/tightness can be assessed only by means of clinical examination	■ A defect is most likely to indicate a structural injury
Strength assessment	Manual resistance is applied distally to the injury site; multiple test positions are utilized to assess isometric strength and pain provocation; pain provocation is as relevant as noting weakness (Fig. 51.3)	
	Important issues: Injury location:	
	Muscle belly	This is typical of some functional injuries
	Muscle–tendon junction?	This is typical for structural injuries/tears
	Tendon–bone junction?	This is typical for tendinous avulsions
Range of motion	For hamstring injuries, passive straight leg raises (hip) and active and passive knee extension test (knee) are commonly used to estimate hamstring flexibility and maximum length	
Muscle length	Should be based on the onset of discomfort or stiffness reported by the patient. Acute injuries' tests are often limited by pain and may not provide a valid assessment of musculotendon extensibility	
Pain provocation maneuvers	Biceps injury can lead to more pain during stretching than contraction, while SM or ST injuries have more pain during contraction than stretching	

Many authors, since 1966, tried to better identify the severity of the injury considering diverse attributes such as the degree of pain, disability, swelling, ecchymosis, presence of a palpable defect or other features of the clinical history such as the type of trauma, ability to continue activity after the injury, and, not least of all, range-of-motion limitation and anatomic location of the tear in the muscle unit [1, 7].

Generally, a *grade I* or "mild" muscle injury has been considered to correspond to stretching or minimal disruption of muscle fibers and a clinical presentation marked by minimal, well-localized pain, contracture and hemorrhage, minor disability, a full pain-free range of motion (or <10° ROM deficit), and ability to continue the sporting activity immediately after the injury. *Grade II* or "moderate" injury has been considered as a tear of a considerable number of muscle fibers but no complete muscle rupture; a more severe clinical presentation occurs when compared with the previous grade, represented by moderate pain, disability, painful range of motion (or 10–25° ROM deficit), and inability to continue the sporting activity. *Grade III* or "severe" injury has been defined to be a complete muscle

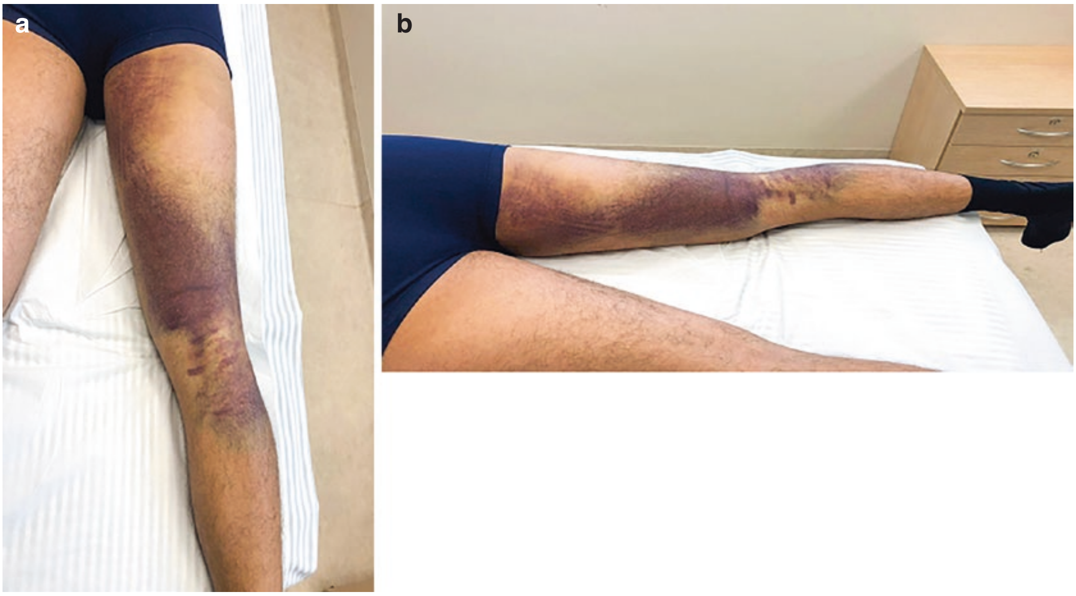

Fig. 51.1 A 45-year-old male presenting with enlarging areas of ecchymosis over inner and posterior aspects of the right thigh after a long head biceps femoris injury; (**a**) clinical inspection (posterior view) of a large bruising on the inner and posterior aspects of the right thigh; (**b**) lateral view

rupture, with the worst clinical scenario, recognized by the athlete's fall in pain immediately after the injury, more than 50% loss of motion (or <25° ROM), a rapid muscle circumference decrease of more than 12 mm when compared to the healthy contralateral muscle, diffuse pain, and hemorrhage (Figs. 51.1, 51.2, and 51.3) [7].

All these clinical presentations and physician's findings about the muscle injury described since the 1960s are estimated tools for an initial evaluation, mainly because of their reproducibility and simplicity, resulting in a quick approach. However, they were based only on specialist opinion and did not have a validated prognostic value [7].

Although the diagnosis is usually clinical, many physicians have an ultrasound in their office and this is especially important when the diagnosis is unclear, when recovery is taking longer than expected and when interventional or surgical management may be necessary [4]. It has advantages such as non-radiation, portability, excellent resolution of neuromuscular structures, and possibility for the examiner to perform dynamic examinations [6].

Fig. 51.2 Presence of a gap detected at physical examination in the place where the patient reports pain, featuring a more severe quadriceps muscle injury

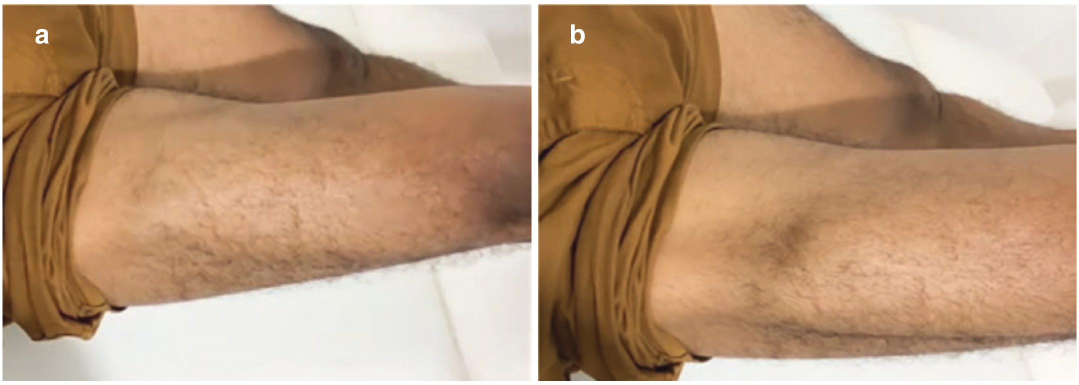

Fig. 51.3 A 32-year-old male soccer player presenting a distally retracted muscle belly after a subtotal muscle tear of the rectus femoris; (**a**) relax muscle; (**b**) active contraction for right-leg raises

Table 51.2 The Munich classification [7, 9]

Type of injury	Definition and symptoms	MRI
Direct	***Contusion:*** Blunt external force, muscle intact ***Laceration:*** Blunt external force, muscle rupture	Hematoma Hematoma
Indirect		
Functional	***Type 1: Overexertion-related muscle disorder***	
	1A: Fatigue-induced muscle disorder Muscle tightness	Negative
	1B: Delayed-onset muscle soreness Acute inflammatory pain	Negative or edema
	Type 2: Neuromuscular muscle disorder	
	2A: Spine-related neuromuscular muscle disorder. Increase of muscle tone due to a spinal disorder	Negative or edema
	2B: Muscle-related neuromuscular muscle disorder. Increase of muscle tone due to altered neuromuscular control	Negative or edema
Structural	***Type 3: Partial muscle tear***	
	3A: Minor partial muscle tear Tear with small maximum diameter	Fiber disruption
	3B: Moderate partial muscle tear Tear with increased maximum diameter	Retraction and hematoma
	Type 4: (Sub)total muscle tear avulsion	
	Complete muscle diameter involvement, defect	Complete discontinuity

51.5 Classification

Over the last decade, the "Munich Muscle Injury Classification" was established by an international group of experts in sports medicine, establishing an alliance with the International Olympic Committee (IOC) and the Union of European Football Associations (UEFA) (Table 51.2) [7–9]. Magnetic resonance imaging (MRI) is a crucial exam to assess the degree of muscle injury.

This classification is characterized by two main branches according to the nature of the muscle trauma: direct or indirect. Additionally, indirect muscle injuries are subdivided into four types according to MRI appearance where types 1 and 2 represent MRI-negative functional disease, and types 3 and 4 represent structural injuries that can be classified as minimal (type 3a), moderate (type 3b), or complete (type 4) [7–9].

Key Points

- Muscle injuries are among the most common injuries in sports and remain a notable issue since it causes competition time loss and a relatively high recurrence rate, despite all technological advances of science in this field.
- Indirect muscle tear is related to muscle strain/stretching; the most common area injured is the myotendinous junction.
- Direct muscle tear or muscle contusion is caused by a direct blow; the severity is determined by the force of impact, size of the striking body, and muscle's state of contraction.
- The examiner should start with a precise history of the circumstances surrounding the injury, before reviewing the symptoms and identifying any previous related injury problems.
- The next step in diagnosis is a careful clinical examination of the injured area. This should include an inspection, palpation, a comparison with the contralateral side, and functional testing of the muscles.
- The main purpose of the physical examination is to determine injury location and try to define severity. Acute injuries' evaluation is often limited by pain, and accuracy of the tests is quite variable.
- Diagnosis is based on history and meticulous clinical examination. Crucial imaging exams for evaluation are US and MRI. US is fast and cost effective, can offer a dynamic muscle assessment, and represents a good tool for serial evaluation to follow healing. MRI imaging is considered the gold standard method to assess the muscular architecture and to evaluate the extent of muscle injuries.
- Classifications and grading systems are currently going through a continuous progression. Additional studies may help validate new grading systems to develop a universally applicable terminology with more clinical relevance.

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