MUSCLE INJURIES IN ATHLETES

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ABSTRACT

This article had the aim of demonstrating the physiology, diagnosis and treatment of muscle injuries, focusing on athletes and their demands and expectations. Muscle injuries are among the most common complaints in orthopedic practice, occurring both among athletes and among non-athletes. These injuries present a challenge for specialists, due to the slow recovery, during which time athletes are unable to take part in training and competitions, and due to frequent sequelae and recurrences of the injuries. Most muscle injuries (between 10% and 55% of all injuries) occur during sports activities. The muscles most commonly affected are the ischiotibial, quadriceps and gastrocnemius. These muscles go across two joints and are more subject to acceleration and deceleration forces. The treatment for muscle injuries varies from conservative treatment to surgery. New procedures are being used, like the hyperbaric chamber and the use of growth factors. However, there is still a high rate of injury recurrence. Muscle injury continues to be a topic of much controversy. New treatments are being researched and developed, but prevention through muscle strengthening, stretching exercises and muscle balance continues to be the best "treatment".

Keywords - Musculoskeletal System/injuries; Wounds and Injuries; Athletes

INTRODUCTION

Muscle injuries are among the commonest complaints attended within orthopedics and occur both in athletes and in non-athletes[1,2]. These injuries form a challenge for specialists given the slow recovery, which keeps athletes away from training and competitions, and the frequent sequelae and recurrences of injuries that occur despite the wide variety of treatments used[3,4].

Most of these injuries occur due to excessive stretching or direct trauma to the muscle belly[5]. Warm-ups and active and passive stretching exercises before training sessions have been put forward as strategies for injury prevention. However, there is little evidence regarding the extent to which such practices really diminish the incidence of muscle injuries[6].

With increasing numbers of participants in sports activities, there has been an increase in the number of patients seen in relation to muscle injuries. Thus, orthopedists need to be aware of the possible treatments, their different stages and their difficulties[7].

The aim of this study was to demonstrate the physiology, diagnosis and treatment of muscle injuries, focusing on athletes, their demands and their expectations.

ANATOMY

The percentage of total body weight accounted for by skeletal muscles ranges from 40 to 50% in men and 25 to 35% in women[8]. Some studies have demonstrated that this percentage increases according to the activity performed by the athlete, and that it can reach 65.1% in weightlifters[9].

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Work received for publication: June 08, 2011; accepted for publication: June 28, 2011.

The authors declare that there was no conflict of interest in conducting this work

This article is available online in Portuguese and English at the websites: www.rbo.org.br and www.scielo.br/rbort

The function of the musculature is to cause contractions through converting chemical energy into mechanical energy, which may or may not result in joint movement[10].

Muscle fibers can be divided into two types: 50% of muscle tissue is composed of slow-contraction fibers (type I) and 50% of fast-contraction fibers (type II). Postural muscles present a larger quantity of type I fibers, which present a slow contraction speed but greater resistance to fatigue. Type II fibers (fast contraction) can be subdivided into types IIA and IIB. Type IIA fibers, also known as intermediate layers, present larger quantities of mitochondria and myoglobin than seen in type IIB, and for this reason they are more resistant to fatigue.

Although muscles present a distribution of fiber types, fiber rearrangement may take place in accordance with the athlete's type of performance. Type II fibers may be transformed into type I fibers through training. On the other hand, the inverse cannot happen[9,11].

Muscles are capable of carrying out different types of contraction. In isometric contraction, the force is generated by the muscle to the same degree as the resistance that opposes it. No movement is generated and there is no change in muscle size. In concentric contraction, the force generated by the muscle is greater than the resistance, thus causing muscle shortening. In eccentric contraction, the resistance exceeds the force generated by the muscle, thus resulting in muscle stretching. The types of injury depend on the type of movement that is being made[11].

INJURIES

The largest portion of muscle injuries occur during sports activities, corresponding to 10 to 55% of all injuries[12]. The muscles most commonly affected are the hamstrings, quadriceps and gastrocnemius. These muscles go across two joints and are more subject to acceleration and deceleration forces[13,14].

The hamstring injuries present great variety of incidence and may correspond to 12 to 16% of injuries in sports like soccer, rugby and athletics[6,14].

Several classification systems have been proposed for muscle injuries. The classification can be done according to the time, type, severity or location of the injury.

With regard to time, injuries can be classified as acute, with less than three weeks of evolution, or chronic[15].

With regard to type, injuries can be classified as those caused by either extrinsic or intrinsic factors. The extrinsic factor group includes injuries that occur through an external event: bruises are the best example. The intrinsic factor group includes muscle dysfunction, strain and tears[13,16].

Muscle bruising is caused by traumatic contact of an object on the muscle group. The biomechanics of the trauma have to be taken into consideration in assessing the possible injuries. By the nature of trauma, both the skin and the deeper layers down to the musculature may suffer varying degrees of injury[13,16].

Examples of muscle dysfunction include cramps, muscle fatigue and compartment syndrome. These are injuries that at first do not affect the structure of the muscle fibers. Cramps are sudden involuntary contractions of the musculature that cause varying degrees of pain. Several theories have attempted to explain the causes of this abnormality: dehydration, decreased serum sodium and/or potassium, neuronal excitation, etc. Prevention of this condition through stretching exercises, muscle strengthening and correction of muscle imbalance has brought good results[16].

O'Donoghue[17] classified injuries according to their severity into three types. Type I (strain) affects few fibers (< 5%); it is caused by excessive stretching of the muscle fibers and gives rise to pain on contraction (against resistance) and on passive stretching; it presents mild edema, minimal damage to the tissue and mild or absent hemorrhage, and there is no loss of function. Type II (partial tear) affects between 5 and 50% of the muscle; it is mostly caused by maximal contraction (through lack of coordination between agonists and antagonists); its symptoms include edema, pain that worsens against resistance, moderate hemorrhage and pain-limited function. Type III (complete tear) consists of complete rupturing of the muscle fibers, presence of a visible or palpable defect, major edema and hemorrhage and complete loss of function[13,16].

PHYSIOLOGY OF INJURIES

The biological changes that occur in the musculature after an injury always follow the same pattern, independent of the type of injury suffered[12]. These changes can be didactically divided into three stages: destruction, repair and remodeling.

The destruction phase is characterized by rupture and necrosis of the muscle fibers, which is followed by formation of a hematoma between the broken muscle stumps and an inflammatory cell reaction[12,13].

Muscle injuries caused by bruising vary according to whether there was muscle contraction during the trauma. If the muscle was relaxed, the injury will affect more muscle layers, since the force is transmitted to the bone by the muscle layers. If the muscle was contracted, the injury is superficial, since the energy is absorbed by the musculature and does not cross all the layers[12,18].

Bruises usually affect the muscle belly, while strain-type injuries usually affect the muscle-tendon junction[12,13].

At the same time as muscle cells injuries occur, capillaries are ruptures and release inflammatory cells at the injury site. This reaction is amplified by release of cytokines and interleukins originating from the injured myocytes, through their macrophages and fibroblasts.

Once the destruction phase has diminished, effective repair of the injured muscle can begin, with two concomitant processes: regeneration of the broken muscle fibers and formation of a scar of connective tissue.

A group of undifferentiated reserve cells called satellite cells is allocated underneath the basal lamina of each muscle fiber during fetal development. In response to the wound, these initial cells proliferate and then differentiate into myoblasts[12,16].

It has been demonstrated that the regenerative capacity of skeletal muscles in response to injury becomes significantly reduced with age. This diminution of capacity seems not to be attributable to reduced numbers or activity of satellite cells but, rather, to a general reduction in the regenerative capacity of aged muscle tissue, such that each phase of the repair process seems to become less forceful and to deteriorate with age.

Within the first day, inflammatory cells including phagocytes invade the hematoma and start to eliminate it. Fibrin derivatives from the blood and cross-linked fibronectin form early granulation tissue that acts as scaffolding and anchorage points for invading fibroblasts.

The scar of connective tissue that is produced at the injury site is the weakest point of the injured skeletal muscle just after the trauma, but its tension increases in strength considerably with the production of type I collagen. Around 10 days after the trauma, the maturing of the scar reaches a point at which it is no longer the weak point in the injured muscle but, rather, if loaded to failure, the breakage would generally occur within the muscle tissue adjacent to the recently formed connection[12].

Although the great majority of injuries to skeletal muscles heal without formation of functionally incapacitating fibrous scars, there may sometimes be excessive proliferation of fibroblasts, thereby resulting in formation of dense scar tissue within the injured muscle. In such cases, which are generally associated with severe muscle trauma or re-rupture, the scar may create a mechanical barrier that considerably delays or even completely restricts regeneration of muscle fibers on the other side of the injury.

Restoration of the vascular supply to the injured area is the first sign of regeneration and is a prerequisite for subsequent morphological and functional recovery of the wounded muscles[18].

DIAGNOSIS

Early diagnosis and prognosis in relation to the injury are valuable information that should be passed on to the medical department, club and athlete, given that the injury may make training and competitions impossible, thus also generating additional costs[16].

Muscle injuries account for the greatest percentage of injuries among soccer players: 47%, in the latest survey by the National Committee of Soccer Physicians (CNMF), Brazilian Soccer Confederation (CBF), over two consecutive Brazilian championships[19]. However, the length of time for which the athlete will be absent from training and competitions, the economic impact on the club and the psychological impact on both the athlete and the team need to be taken into consideration[13,20].

The most evident clinical condition is pain, which arises as the first sign and tends to diminish with the passage of time. It may occur spontaneously or be shown through palpation at the injury site or contraction or stretching of the musculature affected[13,15].

Auxiliary examinations that can be used include radiography, ultrasound, magnetic resonance imaging and computed tomography[6,13].

Radiography makes it possible to view bone injuries and subcutaneous changes such as soft-tissue edema and calcifications[13].

Ultrasound, preferably done by a radiologist with experience in skeletal muscle evaluations, can be used for real-time assessments on tendons, muscles and soft tissues. It is also capable of detecting the presence of fluid accumulations and can be used to guide biopsies[13].

Computed tomography was used more in the past to view bone injuries and the presence of calcifications. However, it has been replaced by magnetic resonance imaging for soft-tissue evaluations. This allows evaluations on the injury in greater detail and is more sensitive to the variations caused by the inflammatory process[21].

TREATMENT

Immediately after the injury, the physician's duty is to avoid amplification of the injury, either through inappropriate exercises or through propagation of the inflammatory response. For this reason, the first 24 hours after the injury are critical[13,15].

Efforts need to be directed towards reducing the bleeding at the injury site. For this, the P.R.I.C.E. protocol is used (Protection, Rest, Ice, Compression and Elevation). At this time, a significant level of analgesia should be administered for the athlete's comfort[13].

Some studies have demonstrated that using anti-inflammatory agents is not as effective as using analgesics in cases of muscle injury. They have also demonstrated that despite the short-term value of analgesics, they interfere with the healing process and may lead to diminished muscle function[4,22].

In the first phase of the treatment, mobilization of the affected limb should be avoided. Early mobilization may cause increased formation of scar tissue, thereby making it difficult for capillary vessels to pass through[23]. Braces can be used to maintain the immobilization. Nonetheless, the immobilization should not be prolonged because this may cause joint stiffness and muscle hypotonia[13].

Mobilization should be started three to four days after the injury, always passively and after gentle warm-up and stretching of the musculature. This early mobilization will favor growth of the capillary vessels and better regeneration and organization of the muscle cells[12]. Isometric exercises should be started, even without any load. As soon as these exercises can be done without pain, isometric exercises can be started[12,13].

Once patients are able to stretch the affected musculature as much as the contralateral side and can do basic exercises without pain, they can start training directed towards their particular type of sport, in which specific work using isokinetics can be used to accelerate the recovery[12].

Surgery is indicated for completely torn tendons, such as for the gastrocnemius tendon, or for cases of pullout. In animal models, Menetrey et al[24] demonstrated the benefit of early surgery, which gave rise to less scar tissue and a faster functional response from the injured musculature.

New therapeutic methods are being studied. Among these, the use of hyperbaric chambers, growth factors, gene therapy and antifibrinolytic agents has been cited.

Use of hyperbaric chambers is a recognized treatment for conditions such as divers' disease and carbon monoxide poisoning. Today, this therapeutic method is being used in an attempt to aid in the recovery from muscle injuries through reducing the inflammatory response and increasing collagen production. Bennett et al[25] were unable to demonstrate that it was functionally effective in a study on muscle injuries. Some other studies have shown a slight improvement in muscle regeneration, but none of them have produced statistically significant improvements[26,27].

Growth factors are proteins released at the injury site. They have a variety of functions, such as: chemotaxis, cell differentiation, angiogenesis, stimulation of protein secretion and cell growth in the skeletal muscles. However, as well as their mitogenic potential, they may also produce side effects such as inhibition of cell multiplication and differentiation[11,18].

Transformation growth factor beta (TGF-β 1) is one of the main cytokines involved in regulating the formation and degradation of the extracellular matrix and therefore, of fibrotic processes. Use of antifibrinolytic agents that inhibit this molecule may lead to less fibrosis and better muscle healing. Agents like suramin are being investigated and promising results have been obtained from *in vitro* studies[28].

COMPLICATIONS

The majority of the complications relating to muscle injuries originate in the hematoma of the injury. This may increase in size and cause compartment syndrome, or it may evolve into an encapsulated hematoma.

If the patient has an infection at another site, there may be contamination and suppuration, which then gives rise to an indication for surgical drainage[29].

There may be rupture or loosening of the muscle fascia, which enables extravasation of part of the muscle belly through the opening in the fascia, thus causing pain and functional abnormalities[3,30].

PREVENTION

Some activities that are taken to be true facts, such as reduction of the chances of injury through stretching before and after physical activity, have had their validity contested in recent studies[31] .

Strengthening of the musculature of the adductors and hamstrings helps to reduce the numbers of injuries in athletes[32,33]. Asymmetry of muscle strength is responsible for muscle injuries. Studies that have investigated muscle balance have demonstrated decreases in the rate of new injuries[34].

Active and passive warm-up of the musculature before training and competition has been disseminated as an injury prevention strategy, but there is little evidence to demonstrate any reduction in muscle injuries[6,35].

Strengthening of the hamstring musculature has been shown to reduce the incidence of injuries to this muscle group[6,36,37].

CONCLUSION

Muscle injury continues to be a topic of much controversy. New treatments are being researched and developed, but prevention through muscle strengthening, stretching exercises and muscle balance continues to be the best "treatment".

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