Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIII, ISSUE 2, 2023, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST
DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXIII, ISSUE 2, 2023
June 2023, 23 (2): 166 - 171
Original article

MUSCULAR INJURIES IN THE CONTEXT OF COVID-19 AND THE IMPACT ON THE ACCIDENT RATE IN ATHLETES

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Abstract

Problem statement. COVID-19 is a disease with multiple organ damage and can lead to complex musculoskeletal, respiratory, cardiac, neurological, psychological sequelae and finally to disability and alteration of the quality of life. Through this work, we wanted to highlight the current state and future perspectives in the chosen issue, in the context of the pandemic evolution. After studying the specialized literature, we chose to focus on muscle injuries in athletes, being a topical issue in the context of the pandemic situation, and the post-COVID-19 complications turn it into a perspective issue. The COVID-19 pandemic has taught us a major lesson in the need to adapt to the new, especially in the performance sports sector. The restrictions during the state of emergency forced athletes to return home, which prevented them from training effectively. Because of this, a very large palette of athletes suffered muscle injuries after resuming training.

The aim of the research. Systematic review of data from the specialized literature with the aim of summarizing the most relevant and newest information about muscle injuries in the context of the current pandemic. Identification of some correlations, with practical applicability, between the studied aspects and muscle injury recovery programs.

Conclusions. Currently, it is difficult to indicate a common protocol that can guide the kinetotherapist to choose the most appropriate way to recover muscle injuries post-COVID-19, identify some correlations and practical applicability between the aspects studied and the use of physical therapy and physical exercise in the post treatment - COVID-19 has brought new hopes aimed at the long-term therapeutic management of patients.Post-COVID-19 muscle injuries must be treated with all seriousness, following both the recovery plan and the reintroduction plan. Physical therapy and physiotherapy play a critical role in the recovery of the athlete with muscle injuries post-COVID-19.

Key words: athletes, COVID-19, muscle injuries, recovery, training.

Problem statement

"While COVID-19 is primarily a respiratory disease, numerous studies have documented and reported the various extrapulmonary manifestations and symptoms". (Bai, Yao, Wei, et al. 2020). Clinical manifestations of COVID-19 typically include musculoskeletal symptoms (MSK) such as myalgias, arthralgias, and neuropathies/myopathies. One study noted that out of 12,046 patients, myalgia and/or arthralgia were present in 15.5% of patients. Consequently, it is critical that clinicians continue to understand and investigate the musculoskeletal symptoms and presentation of those infected with COVID-19. "Additionally, it is imperative to investigate the pathology and potential mechanisms of the impact that COVID-19 has on the musculoskeletal system". (gobbi et al. 2019). Previous studies have shown that virus infection induces a proinflammatory state in patients with systemic effects as a result, the inflammatory response and its impact on the respiratory system have been the focus of most studies. However, the literature is more limited regarding the inflammatory response and its implications for other organ systems, particularly the musculoskeletal system. Previous studies have described how systemic inflammation may play a role in bone and joint pathology. Inflammation has also been linked to skeletal muscle damage and disease.

The aim of the research

Through this work, we wanted to highlight the current state and future perspectives in the chosen issue, in the context of the pandemic evolution. After studying the specialized literature, we chose to focus on muscle injuries in athletes, being a topical issue in the context of the pandemic situation, and the post-COVID-19 complications turn it into a perspective issue. The COVID-19 pandemic has taught us a major lesson in the need to adapt to the new, especially in the performance sports sector. The restrictions during the state of emergency forced athletes to return home, which prevented them from training effectively. Because of this, a very large palette of athletes suffered muscle injuries after resuming training.

Muscle weakness, fatigue or myalgia, and muscle atrophy are among the symptoms most commonly reported by patients with COVID-19. For example, the prevalence of myalgia among currently published reports can range from

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21% to more than 50% of affected patients. Furthermore, myalgia tends to persist after cessation of viral shedding for an average of 23 days. Among patients with severe COVID-19, 19.3% had evidence of muscle damage. Similar findings have been reported for patients with COVID-19 in other intensive care units. In addition, hematological biomarkers of inflammation, cardiac and muscle damage have been shown to be significantly elevated in both severe and fatal COVID-19 patients. Consistently, some reports have described patients with myositis and rhabdomyolysis related to COVID-19.

"Muscle injuries are microtraumas of internal origin produced by a sudden contraction of a muscle, in certain favorable and predisposing situations". (Avramescu & Neamțu, 2019). "Among the predisposing causes we mention the existence of a spasmophilia, a deficient local blood circulation, as well as a series of biological and humoral deficiencies, which sometimes relate to a modified metabolism of sialic acid, hypovitaminosis, etc.". (Enescu Bieru, Gusti, Neamțu, & Dănoiu, 2020). Among the favoring factors we mention the sudden and violent effort without a prior warm-up, in the conditions of a cold and humid climate. Claudatus and Kirshberg showed that muscle strength decreases in direct proportion to the decrease in temperature and changes in atmospheric pressure modify the process of tissue oxygenation. ,,Other causes have also been blamed, including: the presence of catabolism products (results from muscle work), which produce a decrease in muscle elasticity and the coordination of muscle groups, thus explaining the appearance of muscle injuries during and towards the end of training or competition, the methodological mistakes characterized by the unequal training of certain agonistic groups, to the detriment of antagonistic groups". (Ionescu & Caramoci, 2017). Thus, the large number of muscle injuries that occur in some sports (football, athletics, rugby, etc.) especially in the posterior muscles of the thigh, is due to a large difference in tone and strength of these groups, resulting from the neglect of their training, although the agonist muscle (quadriceps crural) is requested par excellence in these sports.

The common factor that creates the same effect, muscle breakdown, resides in the lack of synergism between the work of agonists and antagonists. "It is enough that the contraction of a muscle group or kinematic chain is not doubled by a corresponding elongation - relaxation of the antagonistic group, for a "seizure" phenomenon to occur, resulting in different degrees of rupture of the muscle that opposes the movement fundamentals". (Băcănoiu, 2019). This lack of synergy is more clear at the beginning of training or competition, when the athlete has not warmed up well, so the synapses have not been permeabilized and the complex and coordinated image of the movement has not been established. The lack of synergism is also manifested at the end of the competition, when the prolonged effort starts to decrease the higher nervous control of coordination, as well as the efficiency of the local reflex mechanisms (muscles-joints-muscles). Among the contributing causes, food shortages, special weather conditions, inappropriate sports equipment, excesses and non-sporting life, as well as some omissions in the recovery process, are also incriminated.

Muscle injuries are classified according to their surface, the muscle injury can be:

- fibrillar (when several fibers are damaged);
- fascicular (when several fascicles of the muscle are involved);
- fibrofascicular (which reunites one or two broken bundles);
- total injury.

These types of injuries subjectively correspond to: intense pain in the respective muscle and the functional incapacity of the anatomical segment of which the respective muscle is a part.Classically, the following symptoms are described for the most common fibrillar and fascicular muscle injuries:

- sharp burning pain;
- antalgic attitude;
- the presence of a painful point on palpation;
- swelling of the region;
- local ecchymosis;
- appearance of hematoma.

In the case of total muscle tear, sharp pain, like a knife cut, together with palpable bump are pathognomonic signs. Until recently, the severity and severity of muscle injuries were specified in a subjective manner, following the clinical examination.

Methods of diagnosing muscle injuries

Soft tissue ultrasound

It can be used as a first-level diagnostic tool and together with the clinical examination can be useful to monitor the healing process of the lesion. However, clinicians should be aware that there may be differences between clinical and imaging features. Ultrasound allows staging for almost all muscle injuries and evaluation of their evolution and complications. Ultrasounds have a sensitivity of 77% for non-structural lesions and 93% sensitivity for structural lesions. Ultrasound allows the diagnosis of a structural injury to the muscle 36 to 48 hours after the trauma, because the peak of the hemorrhagic edematous collection is seen after 24 hours and up to 48 hours, when it will begin to shrink.Dynamic ultrasound examination: to evaluate the dislocation of the tertiary bundles and the extent of the lesion. Color Doppler and power Doppler have an important role to visualize the course of the arteries and veins and to quantify the amount of blood in the muscles; describe hypervascularity in the scar tissue of the lesion: this could indicate whether the reparative scar tissue at the site of the lesion is unstable.

Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is a multi-parametric diagnostic tool for detecting minimal changes. It has a sensitivity of 92% for non-structural lesions. MRI allows for the broad assessment of deep muscles that are difficult to examine with ultrasound scanning. MRI can be used to measure changes in muscle volume, structure and signal intensity and to accurately define the extent of the lesion.

MRI indications:

- the prognosis of non-structural injuries in professional and high-level athletes;
- ruling out a structural injury in high-level professional athletes, when clinical findings and ultrasounds are discordant;
- evaluation of muscles difficult to examine sonographically.

Research directions

We were interested in consulting data from the specialized literature with the aim of summarizing the most relevant and newest information about muscle injuries in sports rehabilitation during the COVID-19 Pandemic. Up to the present moment, we have identified 2 research directions in the field of the topic addressed. The method of searching/using bibliographic sources was online on a usual engine - Google Scholar using as keywords: covid effects on muscular tissue: muscle damage during the covid-19 pandemic; rehabilitation after COVID muscle damage in athletes.In this context, we identified 2 research directions and selected 9 relevant studies for the studied problem.

Research direction 1 - Neuromuscular manifestations in the context of COVID-19.

Research direction 2 - Recovery of muscle injuries during the COVID-19 pandemic.

Research Direction 1

Muscle weakness, fatigue or myalgia and muscle atrophy, peripheral nerve diseases, muscle injuries, myositis and rhabdomyolysis, exacerbations of myasthenia gravis. In a retrospective study by Zhang et al., muscle pain was one of the independent predictors of worsening symptoms and disease status in patients with COVID-19. In a Chinese retrospective case series by Mao et al., ,,one of the first reports, conducted on 214 patients with COVID-19 hospitalized in Wuhan, 8.9% had peripheral nerve disease and 7% had muscle damage. Furthermore, among patients with severe COVID-19, 19.3% had evidence of muscle damage. Similar findings have been reported for patients with COVID-19 in other intensive care units". (Mao, Jin, Wang et al. 2020).

In addition, hematological markers of inflammation, heart and muscle damage have been shown to be significantly elevated in both severe and fatal COVID-19 patients. Consistently, some reports have described patients with myositis and rhabdomyolysis related to COVID-19. All of these patients had elevated serum levels of CK as well as elevated serum levels of CRP, LDH, and ferritin. In addition to myositis and rhabdomyolysis, critical myopathies and sarcopenia have also been described in patients with COVID-19. Although there are no current reports of cases of myasthenia gravis caused by COVID-19, episodes of exacerbation of pre-existing myasthenia gravis related to SARS-CoV-2 have recently been reported. On the other hand, the immune dysregulation caused by COVID-19 can trigger or aggravate autoimmunity disorders and rheumatism in genetically susceptible subjects. ,,Several atypical clinical and laboratory manifestations of disease mimicking rheumatic skeletal muscle diseases (RMDs) have been reported, including musculoskeletal and cardiovascular manifestations as well as autoinflammatory/autoimmune syndromes". (Gobbi, Bezzoli et al. 2021).

In addition, laboratory reports of positive antinuclear antibodies (ANA), antiphospholipid antibodies, lupus anticoagulant test, and elevated D-dimer level have been reported with COVID-19, suggesting the risk of persistent immune dysregulation in the medium and long term. In addition, potential adverse effects of antiviral or immune-modulating therapies used to treat COVID-19 should be carefully monitored and analyzed, as several findings of musculoskeletal adverse reactions have been reported following the use of these drugs.

Research Direction 2

We certainly know more now than when the pandemic began, but much is still unknown about the long-term effects of the disease, COVID-19. We know that the virus can cause damage to the heart, brain, lungs and kidneys, but there is no way to identify or predict exactly who these individuals will be. Some people may also experience persistent symptoms, including shortness of breath, muscle pain, loss of stamina and exhaustion – all of which are bad news, but especially for athletes and active people. Myocarditis is an inflammatory response of the heart due to a viral infection, such as COVID-19. It can cause the heart muscle to swell, making vigorous activity more difficult and sometimes even fatal. Given this potentially increased risk of myocarditis, athletes returning from COVID-19 infections should be cleared by a healthcare provider who will determine if further testing is needed. Because of the risk of myocarditis, athletes and anyone who exercises should follow a gradual return to physical activity over a week to monitor for signs and symptoms of this serious complication. It is of the utmost importance to start training early after contracting COVID-19, but at the same time pay attention to physical barriers to ensure a safe return to exercise.

"For exercise recommendations beyond rehabilitation programs, particularly for leisure and elite athletes, more precise advice is needed, including assessment of sport eligibility and specific exercise programs for return to sport".

(Goodwin, Allan et al. 2021). Because of the current uncertainty regarding the long-term evolution of SARS-CoV-2 infection or COVID-19 disease, long-term follow-up appears to be necessary. From our perspective, in elite and recreational athletes, a basic routine medical reevaluation, including a resting ECG and blood analysis, should be performed after 3-6 months to assess the currently unknown long-term effects of SARS-CoV-2 infection. However, many athletes, especially youth, have no or very few symptoms initially, so in these cases individualized guidance based on initial symptoms may be more meaningful. If further examinations are required after this period, it must be decided individually. In case of pulmonary or myocardial disease, in addition to ECG and echocardiography, annual, at least in the first two years, in-depth cardiological examinations, including exercise tests with arterial blood gases and optimally spiroergometry, are recommended. Elite athletes will typically be tracked at least annually.

The principles of recovery of muscle injuries post - Covid-19

Recovery goals for patients with post-COVID-19 muscle injuries:

- Combating pain and inflammation;
- Combating retraction;
- Restoration of contraction force;
- Restoring exercise resistance (RM);
- Restoring flexibility;
- Restoration of movement coordination.

Combating pain and inflammation

a. Muscular tendon pain - limits active movement, not passive movement (periarthritis, traumatic tendinitis, pain contracture):

- tendon rest (avoidance of active or passive tendon tractions);
- cryotherapy - massage with ice for contracts, ice bag applied locally for tendons (does not apply in muscle ischemia);
- medium frequency - excitomotor formula for muscles - improves circulation and has a decontracting effect, also reduces pain; analgesic formula for tendon;
- massage - anti-algesic, decontracting, improves circulation;
- thermotherapy - in any form, after the acute phase; short waves - medium intensities;
- medication - NSAIDs, decontractants, sedatives.

Combating musculotendinous retraction

- interested in all structures: muscles, tendons, soft tissues - capsule, ligaments, integument, subcutaneous connective tissue);
- massage: all methods (smoothing-kneading-beating-friction-vibration); effects: increased compliance of all tissues; it begins and ends with local heat (procedures that ensure prolonged heat) and traction;
- short waves - deep thermotherapy;
- ultrasound: thermal action, mechanical action and excitation action of muscle-tendinous proprioceptors, fibrinolytic effects; doses of 1-2 W/cm2 are used, possibly pulsed;
- stretching - passive manipulations - simultaneously with heat and continues for some time after removing the heat source; it is done passively: the physiotherapist's hand or a mechanical system with weights.

Rules of stretching maneuvers to gain joint range of motion:

- do not stretch an inflamed muscle, but after the inflammation disappears; it starts gently;
- the stretching of the joint is done up to the threshold of pain and the maneuver is done more gently than with the muscles;
- stretching the muscle can be done for a short period, above the pain threshold and can be done vigorously.

Restoring muscle flexibility – Stretching

- testing - decrease in the amplitude of movement in the direction of movement of the antagonist (loss of muscle elasticity decreases joint mobility), due to: tendomuscular pain = limitation of active movement, muscle retraction = decreases active and passive movement.
- treatment - local analgesics, cryotherapy.
- physical therapy - stretching = muscle stretching leads to the breaking of the transverse bridges between actin and myosin. If continuous stretching is performed beyond the rest length, it does not return to the rest length when it stops.

Types of stretching:

- ballistic - the stretched muscle like a spring throws the segment in the direction opposite to the stretch;
- dynamic - limited voluntary movements of the segment, trying to gently pass over the maximum point of the range of motion;
- active state - voluntary movement towards maximum amplitude; maintain the segment by contraction of the agonists for 10-15 seconds without help;
- passive state - other external force - with the help of another segment, balance, own weight;

- isometric - in the passive stretching position, the isometric contraction is performed with the help of the physiotherapist.

Increasing muscle strength

The increase in muscle strength must be achieved in muscles with inactivity atrophy; in an inactive muscle, it loses up to 5% of its strength/day; at the same time, muscle atrophy occurs with the decrease in muscle volume and the loss of activated motor units. The increase in strength causes the increase in work capacity. To increase the strength of a muscle, one of the 2 conditions must be met: achieving a maximum tension in the muscle; achieving muscle stress with subsequent muscle fatigue.Increasing muscle strength by increasing maximal contraction tension:

A. Isometric contraction - the length of the fibers remains constant, the muscle works against a resistance equal to its maximum force;
B. Concentric contraction - the length of the fiber gradually decreases: the ends of the muscle come closer; the muscle overcomes a resistance with slightly less than maximum force;
C. Eccentric contraction – the fibers lengthen: the ends of the muscle move apart.

Isometric exercises - these exercises are used to increase strength, the isometric exercise must achieve more than 35% of the maximum muscle tension.Isometric exercise with more than 60-70% of maximum muscle tension for strength increase of about 5%/week. The following technique is preferred: 3 contractions of 5-6 seconds each, with a 2-minute break between them; it is repeated several times/day, more often in the first part of the recovery (at 2-hour intervals) and less often afterwards (2-4 times/day); daily repetition. The position of the segments (length of the muscle) in which the isometric is performed is important: at the maximum length of the muscle, maximum tension develops, therefore maximum forces. Concentric and eccentric resistive exercises can be performed with the help of the physiotherapist or with the help of levers or weights. The physiotherapist applies a graded resistance by hand, always kept slightly below the maximum relative force developed by the patient for that segment. If it is performed with levers or weights, it is adjusted according to the force applied by the patient; this variant is not as efficient, because the value of the applied force is not the same throughout the amplitude of a system.

Increasing muscle strength by creating a muscle metabolic stress. Isotonic exercises are practiced, with the shortening of the muscle, the tension remaining unchanged. This type of exercise is based on achieving a metabolic stress at the muscle level, which causes an increase in muscle work. Through these exercises, muscular strength is developed, as well as resistance, speed, and coordination. Muscle fatigue represents the inability to continue physical exercise - the rhythm of labor, the amount of labor and the onset of muscle fatigue represent the condition of muscle toning.

Increasing muscle resistance

It is the ability of the muscle to perform an exercise or activity over a prolonged period of time, but also the ability of the muscle to sustain a contraction. There is a direct relationship between strength and resistance. Resistance depends on: muscle strength, muscle circulation and muscle metabolism and on factors related to the Central Nervous System, such as motivation, cortical inhibition and excitation, the state of illness or health. If the force used is below 15% of the maximum force - the resistance (sustaining a contraction) can be unlimited. If we use 50% of the force, the resistance is 1 minute. If we use maximum force the resistance is 6 seconds. Exercises to increase muscle endurance are done at 15-40% of maximum strength, so that muscle fatigue does not occur too quickly and the cardiovascular response is allowed to occur.

Restoration of movement coordination

,,Regaining motor activity in the affected segment also means regaining coordination, in addition to recovering active movement and strength. Coordination is a complex process involving the integrity of motor and sensory pathways. Activities in everyday and professional life are carried out based on motor schemes that we learn throughout life and repeat throughout it". (Halle et al. 2021). Such a scheme can comprise from a few simple moves to tens of moves. Nervous command and control is done on that pattern, not on each individual movement. To recover coordination, the techniques of Occupational Therapy and ergotherapy are used, through usual exercises. The regaining of normal coordination is done through repetitions of the movement schemes practiced sustained for weeks. The goal pursued is set according to each patient. Recovery of the upper limb and especially the hand. For lower limb coordination - Frenkel exercises. This method is specific to the treatment of patients with diseases of the cerebellum, respectively of the taxa, but being a real success in the recovery of muscle injuries post-COVID-19. Jacob Frenkel observed that lost propriception can be largely replaced by visual connection and visual feedback. The method is based on a series of techniques and exercises with visual control, applying the law of progression of performance and precision. The law of progression, within the method, suffers two deviations: the patient first performs the movement large and fast, which is easier to perform, gradually moving to movements of smaller amplitude, more precise, performed in a slower, coordinated rhythm. During the recovery, the gradual increase in complexity and difficulty, but

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not in intensity. The exercises are performed individually, in a mandatory manner, two or more times a day. The grouping of exercises looks like this:

1. Exercises from the supine position (with the head higher, on a backrest or pillow, so that the execution can be followed) for the lower and upper limbs. The exercises are asymmetrical.
2. Exercises from the sitting position are carried out as follows:
   - at the beginning, the upper limbs, supported by the hands;
   - after that, without support;
   - in the end, the execution takes place blindfolded;
3. Orthostatism exercises - in this position, walking re-education is carried out, which is carried out on diagrams (width 22 cm, and is divided longitudinally, in steps of 68 cm each). Each step is visibly divided into halves and quarters, drawn on the floor or a wooden board. Re-education starts with lateral walking which is considered easier (ontogenetically it appears faster), the patient being helped by body balance. It starts with half a step, moving one leg and then bringing the other next to the first. It goes to quarter steps and only after that to whole steps. The same goes for teaching walking forwards and backwards. In a more advanced stage, the patient is taught to go up and down stairs and perform turns. The turns are still learned following a diagram in the form of a circle drawn on the floor. The patient learns to turn by moving one leg next to the other for a quarter of the entire rotation, so that he can perform a 180º turn in two steps.

Conclusions

Although it is currently difficult to indicate a common protocol that can guide the kinesiologist towards choosing the most appropriate way to recover muscle injuries post-COVID-19, the identification of some correlations and the practical applicability between the aspects studied and the use of physical therapy and physical exercise in post-COVID-19 treatment has brought new hopes aimed at the long-term therapeutic management of patients.

Post-COVID-19 muscle injuries must be treated with all seriousness, following both the recovery plan and the reintroduction plan. The evolution and prognosis are, in general, favorable, if the athlete is given specialized and quality medical assistance from the first moments of the injury, and the resumption of training must be decided by the doctor with the help of echomyography, the only one that can specify the moment of full recovery. Physiotherapy and physiotherapy play an essential role in the recovery of the athlete with muscle injuries post-COVID-19. Physiotherapy sessions can be a real help in post-COVID-19 injury recovery. Physiotherapy treatment, which includes a wide range of approaches and techniques, plays an important role in the treatment of muscle injuries.

Many relapses occur because of technicians, who, eager to see their player in the basic formation, force re-entry, often based only on the statement of the athlete, who, for easily suspect reasons, states that he feels well, healing lesions rupturing, resulting in a doubling of downtime.

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