ARENA-JPA, ISSN 2285-830X
11, pp. 18-40, 2022

Biological Bases of an Injury: Applications to Resistance Training

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Abstract

Understanding the biological factors of an injury is beyond the aspects that caused this condition in the athlete. Thus, the aim of this study is to develop a solid understanding of the biology associated with the development of an injury derived from the practice of physical exercise and its related aspects. It is verified that the harmful processes affect countless strength training practitioners throughout their periodizations. These injuries lead to departures from the training routine and delays in the development of the practitioners' goals. Lesions mainly affect joint structures, with synovial joints being among the most affected. Reduced muscle strength and impaired mobility are among the factors that contribute to the development of joint damage. Bone injuries are also among the most present in the population practicing physical training, and these are caused by microfractures derived from shear loads common in contact sports. Muscle strengthening, including training variables and biomechanical techniques, help to reduce the incidence of injuries and in their treatment when they are already installed in the physical

exercise practitioner.

Keywords: biomechanical phenomena, morphology, exercise, strength training.

Introduction

The knowledge that a physical trainer or Physical Education professional must have in assisting their students in environments such as gyms and sports centers must be firmly structured in recent research and already consolidated literary support. In this sense, the use of techniques, sometimes more innovative, sometimes more traditional, becomes an excellent tool in the development of works in favor of the physical, psychological and social improvement of the student (Belozo et al., 2020).

One of the characteristics that most stands out in the context of resistance training is the execution of a certain movement in a harmonic way and within the practitioner's joint limits. In addition, a well-produced movement against resistance is associated with benefits to several organ systems, in addition to the muscular, skeletal and joint systems (Mendonça et al., 2020).

However, on the contrary, movements executed in a wrong way, with excessive speed or too slowness, reduced or exaggerated amplitude of the gesture, innovations in the execution of traditional exercises, which are more similar to the performing arts implemented in the movement, leading to overload of structures anatomical features and making the exercise less functional , also attract the attention of passers-by to gyms, bodybuilders, professionals working in the context and digital influencers (Fernandes et al., 2021).

The fact that well-executed movements strike us for the beauty of the gesture, while poorly executed movements awaken in us fun, astonishment and the questioning of how much a human being is capable of withstanding, is not restricted to aesthetic aspects, but also to the potentially harmful factors that the second example can provide to the resistance training practitioner.

As it is already common sense and widely disseminated in scientific circles, physical training, be it resistance, aerobic, aquatic or in any other way, brings countless benefits to the individual who performs it. However, in association with this, the large number of people who are frequently injured practicing sports, fights, dancing and physical exercise in general are also known (Pelegrina et al., 2021).

In this sense, the personal trainer, Physical Education professional or physical trainer must be aware of the peculiarities that involve and derive from a sports injury, as well as prevent it from being developed in their student, athlete or client. For this, a basic understanding of cellular and molecular biology, as well as histological and anatomical characteristics, in addition to extensive knowledge in kinesiology and biomechanics are necessary.

Therefore, the aim of this study was to present the biological bases of the harmful process in resistance training practitioners, based on an integrative literature review.

Method

The present work is an integrative literature review study, exploratory and basic in nature, aiming at the development of future hypotheses for clinical trials and experimental protocols on the subject, as well as a reflection on the topic addressed. For this study, the descriptors *"training", ''physical training'',''injuries'', ''analysis of human movement'', ''biomechanical phenomena''* were used. Standardized descriptors and associated by the search platform used.

For the elaboration of this review, the Pubmed (Medline), DOAJ and Scielo databases were accessed and used, which include original and revision manuscripts, as well as case reports and meta-analyses, in addition to scientific books in English and published in journals of high technical-scientific impact (with an impact factor of 0.7 or higher).

Regardless of, only articles published in the English language were accepted for the preparation of the results of this article. Associated with this, only randomized clinical trials, meta-analyses, systematic reviews and clinical trials were accepted. Classic literature and outside the temporal cutoff, in which ten years were applied (January 2011 to February 2021), were accepted with exclusively conceptual purposes . Integrative review articles and letters to the editor were not considered.

Results and Discussion

The results obtained from the search criteria and the reading of the articles, as well as from the analyses, were synthesized and they are discussed below.

Cellular and molecular aspects related to an injury

Usually, the cells of a human body are in adequate physiological conditions for maintaining homeostasis and recovering it if it is altered. In this way, it is common to identify in cells the cell nuclei positioned in regions that are characteristic, in addition to genetic material internalized in its nucleus with the appropriate constitution and condensation consistent with the moment of the cell cycle. In the cytoplasm of healthy cells, the protein synthesis machinery is normally in full swing. Always synthesizing new proteins, a process that involves the secretory biosynthetic pathway, and recycling old and already used ones, a procedure carried out by organelles such as proteasomes that, in normal cells, act in a manner dependent on biomolecular markers such as ubequitin (Camargo et al., 2020).

Still, in healthy cells, the cytoplasm is organized and contained by means of a cytoplasmic membrane with an organized bilayer with phospholipids, fatty acids and proteins always adequate to the work and activity of each specialized cell. The mitochondria, which are responsible for cellular respiration and the synthesis of adenosine triphosphate, which provides chemical energy for cellular reactions, are working normally, always with their matrix and outer membrane organized, thus avoiding apoptotic processes related to numerous protein cascades (Cunha et al., 2021).

As can be seen, in a normal cell the functioning of molecules and organelles is adequate, all in a natural condition. However, if any degenerating harmful agent affects this order and condition of cell functioning, it may undergo processes that alter its physiology and morphology, and may even lead to death (Cunha et al., 2021; Camargo et al., 2020; Fernandes et al., 2020).

Normally a sports injury occurs in a way that the agent practicing the sport loses control of his body, or is surprised by an object or opponent. However, there are cases in which peripheral or central fatigue is installed, and even with such wear and tear, the athlete remains active, also leading to highly harmful processes. However, the frequent use of a structure for a given activity, for example the anterior surface of the tibia used for kicking punching bags, can also cause microfractures which, after a period of poor recovery and excessive physical and psychological stress, lead to injuries and fractures in this region (Image 01) (Santos et al, 2021).

Image 01: Professional MuayThai athlete executing a side kick at the height of the upper region of the punching bag. Check that the area that comes into contact with the object is distal to the leg, precisely the ankle and end of the tibia. The frequency of loads in a single area can lead to microfractures in the region, which can progressively generate a larger and debilitating fracture (Source: personal files of Prof. Doc. Victor Fernandes and Prof. Filipe Lucas)

A cell subjected to a harmful process modifies its physiological activity in a complementary way. Therefore, biochemical markers expressed in the blood plasma are observed, which indicate the deficient state of a certain tissue or organ. This occurs because the genetic material, deoxyribonucleic acid (DNA), which contains numerous genes that encode numerous other proteins, is stimulated to produce mechanisms of responses to harmful agents and to delay the progression of the lesion. Thus, many proteins are synthesized in an attempt to signal a local injury and prevent a worsening of the condition. For example, it is known that high levels of the creatine kinase enzyme metabolite are associated with muscle tissue stress, often observed in athletes and practitioners of vigorous physical exercise. However, it is observed that altered levels of sodium in the bloodstream are also associated with cellular impairments of various types (Cunha et al., 2021; Fernandes et al., 2020).

This stimulation of genetic material can be caused by the presence of microorganisms foreign to the individual, such as bacteria and viruses, for example, or, as is more frequent in sports injuries, by excessive load or sudden imbalance of the practitioner during movement. In gym environments and resistance training sports centers, injuries can occur due to inadequacy of loads, that is, a poorly designed training sheet that focuses on high intensities daily with little recovery time or a poor diet. In addition to an inadequate anatomical structure, caused by muscle imbalances of practitioners (Gonçalves et al., 2021).

The second case, muscle imbalances, are very common in gym environments. This occurs because the proper adjustment of loads and the frequency with which a given body region is exercised does not always match the limits or needs of the practitioner, and it is up to the coach or professional to make these adjustments (Mendonça et al., 2021; Gonçalves et al., 2021).

An anatomical perspective

It is known that, from an anatomical perspective, the locomotor system consists of three essential systems for promoting movement, namely, the skeletal system, the muscular system and the joint system.

The skeletal system is so named due to the fact that its main constituents are the bones of the human body. Embryologically, the skeletal system derives from the mesoderm, one of the embryonic layers that arise during the gastrulation phase[1]. Skeletal tissue is made up of four basic cell types: osteoclasts, osteoblasts, osteocytes, and bone lining cells. Osteoclasts are cells specialized in reabsorbing bone tissue, thus helping to maintain and remove unused or inadequate bone matrix from the tissue. Osteoblasts, in turn, synthesize bone matrix and mineralize the tissue, that is, they produce new bone tissue on top of the old bone. Osteocytes are mature bone cells, precisely osteoblasts that have become enveloped by bone matrix and begin to help maintain tissue in a paracrine and local manner. Bone lining cells line the tissue (Cunha et al., 2021).

Bone tissue is often exposed to different types of loads that can cause different effects on the bone. In addition, as is already widely known, bones vary according to their type and geometric characteristics, therefore, the loads imposed on bones behave differently according to different types of bones (Cunha et al., 2021; Fernandes et al., 2021).

[1]Essential process in the development of the animal embryo, which in the case of this content, the human being. This is a stage that derives from the blastula, in which the cells that undergo intense mitotic activity position themselves in a more adequate way for their respective functions and, in this way, become specialized. In this phase, the body starts to have axes and anatomical planes.

The so-called long bones, because they have a length greater than the width and thickness[2], are more adapted to undergo axial loads, such as compression loads (Image 02). The short bones[3], as well as the long ones, too. This occurs because the distribution of the load imposed on the tissue takes place over a larger surface, thus avoiding an accumulation of energy in an exclusive region of the tissue (Silva et al., 2020; Dangelo & Fattine, 2007).

Image 02: Long bones of the lower limb. The first bone (at the far left) is the femur. Note that between the fibula (right end) is the tibia, a typical long bone that frequently receives compression loads because it supports a large amount of body weight. (Source: personal archive of Prof. Doc. Victor Fernandes)

[2]Femur, humerus, tibia, radius, ulna and fibula are examples of long bones.
[3]Carpal bones are examples of short bones.

However, flat[4], pneumatic, sensamoid and irregular bones support compressive loads, each to its own capacity. For example, if you observe a vertebral column, you will verify that the irregular bones that constitute it, the vertebrae, support a great load of body weight being imposed on them during most of the day. But, if you look carefully, you will see that as the vertebral column moves caudally, the body of the vertebrae gains more and more volume, area and perimeter, a fact that allows the vertebrae of the lumbar and sacral regions, for example, to , support the body weight of the trunk, upper limbs, head and neck (Image 03) (Silva et al., 2020; Dangelo & Fattine, 2007).

Imagem 03: Lumbar, sacral and coccygeal region of the spine, pelvic girdle being evidenced by the relationship of the (fused) sacral vertebrae to the hip bones (ilium, ischium and pubis). Note that the vertebral body is progressively larger as we view the vertebrae caudally. This is to help support the compressive load exerted by the body. (Source: archive of personal images of Prof. Doc. Victor Fernandes).

The patella, a typical sesamoid bone, has a low capacity to withstand compressive loads, but its ability to handle tensile loads is exemplary. It is, therefore, an axis for leveraging the extension of the lower limb, a fact that the quadriceps uses its passage anteriorly to the patella, going to fix itself on the tibial tuberosity, to promote a moment of very efficient driving force in

[4]Scapula and ilium (hip bone), for example.

the traction of the individual's leg (Image 04) (Silva et al., 2020; Dangelo & Fattine, 2007).

Image 04: Patella located between the femoral condyles, precisely on the patellar surface. Note that the patella acts as the pivot on the lever that is needed to move the tibia and fibula (leg). (Source: personal files of Prof. Doc. Victor Fernandes).

Shear load (also called sliding or tangential) is one of the load examples that are most associated with fractures and serious injuries during sports movements or in daily activities. This occurs because, typically, this load is accompanied by opposing vector forces, that is, the force of a blow contrary to the movement you want to perform. Furthermore, these forces are of the same magnitude, as the third Newtonian law explains (Fernandes et al., 2020; Dangelo & Fattine, 2007).

In combat sports, such as Muay Thai, for example, the presence of this type of load on bone structures present in the region of the lower limbs is commonplace. A very illustrative example is the injury that the professional athlete Anderson Silva suffered in his tibia, due to a great shear load that was imposed on him (Cunha et al., 2021; Dangelo & Fattine, 2007).

Usually an injury is accompanied by symptoms that indicate the presence of tissue abnormalities at the site. Of these symptoms, the most common are local pain, limitation of movement at this location, the area has a high temperature and is red, in addition to accumulation of fluid (blood and lymphatic) in the subcutaneous tissue, characterizing edema (Gonçalves et al., 2021).

These symptoms, in addition to being associated with discomfort in the practitioner of physical exercises, are also the cardinal points or main characteristics of local tissue inflammation. It is worth mentioning that an inflammatory process can be initiated by several causative agents, such as the presence of foreign microorganisms and cellular disruption with extravasation of cellular material, the latter being one of the most common in resistance training environments (Gonçalves et al., 2021; Mendonaça et al., 2021; Silva et al., 2020).

During the movement performed in conditions against resistance, whether a typical bodybuilding exercise or Olympic weight lifting, even Yoga and Pilates exercises in which resistance is usually a body region, there is the possibility of observing the movement in three different conditions , concentric, eccentric and isometric movement. Concentric movement is characterized by the shortening of skeletal muscle fibers so that the angle of the joint at which that muscle is in action is decreased, reducing the distance between the bones that attach the muscle. If you take the biceps brachii and the brachialis muscle as an example, both have their distal attachments[5] on the tuberosity radius and ulna, respectively. Its origins are in the superior margin of the glenoid cavity of the scapula and in the coracoid process and in the medial region of the anterior face of the humerus, also respectively. Note that during the elbow flexion movement, the bones in question come together, together with the shortening of these muscles,

thus characterizing a concentric movement (Image 06). (GONÇALVES, et al. 2021).

Image 06: Note that the sequence of images shows a progressive change in the angle (in yellow) of the elbow joint, during the execution of the movement. The amplitude is reduced and this evidences the concentric movement. Amplitude increases and exposes eccentric movement. (Source: personal files of Prof. Doc. Victor Fernandes and Prof. Ney Lucio).

The eccentric movement, in turn, is an increase in the angle of the joint, distancing one bone from the other, which can be, within its pedagogical limitations, compared to the opposite movement of the concentric. However, eccentric movement is not basically about allowing the

[5]Distal attachments may also be called insertions.

limb to return to its original state after a concentric movement. But rather resisting the return, given that, as studies have already indicated, the eccentric movement is capable of promoting microfiber breakage, which in a tissue recovery process encourages muscle hypertrophy (Fernandes et al., 2021; Fernandes et al.; 2020; Silva et al., 2020).

The isometric movement, however, is characterized as a contraction of the myofibrils, without, however, there is a movement of decrease or increase in the angle of the joint of the muscle involved. In this sense, if a simplified analogy of the isometric movement were made, we would understand that this consists of a movement in which there is muscle contraction, without the movement of the limb. This might sound a little strange to the first-time reader, but try the following experiment. Finish off your body and position yourself to do a push-up. After that, start the movement by descending your torso and flexing your elbow, if you are trained, sustain your torso in the lowest position for a while, without touching the ground. At this precise moment, your pectoralis major and anterior portion of the deltoids, in addition to your triceps brachii and serratus anterior will be in isometric movement, sometimes with greater activation of a certain muscle, sometimes with less of another (Hall, 2012).

This relationship between types of movements and sports injuries has aroused great interest in the scientific and professional community for years. It is already known that the eccentric movement produces greater cellular damage to the muscle fibers, since the rupture of the crossed bridges during the return of the movement, even more increased with high loads, makes the overload principle effective, thus stimulating the muscular hypertrophy. But recent studies have also identified that eccentric training is associated with morphological improvement in muscle tissue, such as increased cross-sectional area, fiber type, improved fibrillar contraction (per unit) and pennation angle. However, it was observed in these studies that eccentric exercise modifies motor neuron activity in a positive way, facilitating its stimulation and direction, since during this phase of the exercise, Rewshal cells would receive stimuli more slowly. Furthermore, eccentric training also promotes greater brain activation, influencing the corticospinal pathway, allowing motor neuron stimulation, as previously mentioned, more adequate (Gonçalves et al., 2021).

Another important aspect in the theme of injuries and sports training are the joint structures and the components responsible for maintaining joint stabilization. A joint, as mentioned earlier in this content, can be classified, from anatomical perspectives, as fibrous, cartilaginous or synovial. This last type of joint has great mobility when compared to other joints in the human body. Your joint structures are properly developed so that the support and movement of these joints is efficient and lasting. (Mendonça et al., 2021).

One of the components of a synovial joint is the articular cartilage present at the ends of the bones that make up the joint. This cartilage is made up of hyaline connective tissue capable of absorbing impacts and adapting the load homogeneously throughout the surface on which it is located. In addition, the articular cartilage is formed by chondrocytes, cells specialized in the production of collagen and cartilaginous tissue (Dangelo & Fattine, 2007; Fernandes et al., 2018).

Injuries to the hyaline cartilage are among the most common in elderly individuals. Such conditions are installed due to microlesions that, coincidentally, are added to larger lesions in this region, until the development of diseases, such as arthrosis, becomes propitious (Riesberg et al., 2016). Associated with this advance, there is the fact that the articular cartilage does not have the ability to regenerate in the elderly population. This occurs due to a decrease in cellular mitotic activity, in addition to the low vascularization of this bone tissue site (Gonçalves et al., 2021).

Another structure that forms part of a synovial joint and is of great importance in maintaining joint stability is the joint capsule. Consisting of two membranes, one fibrous (external) and the other serous (internal), the joint capsule has the function of acting as a cuff containing the structures of the synovial joint. In addition, due to its formation in two distinct membranes, it assumes varied functions that also influence joint dynamism. The outer or fibrous membrane of the joint capsule is made up of connective tissue with greater capacity to withstand traction, given that many tendons and ligaments are inserted in this area. The inner membrane of the joint capsule, in turn, is made up of cells called chondroblasts and chondrocytes, which synthesize the synovial fluid that serves as an important agent for distributing the loads that act on the joint, in addition to lubricating and nourishing all the structures present. in the synovial joints (Dangelo & Fattine, 2007).

The connective tissue that connects the bones that make up the synovial joints, are also characterized as important elements in this context. Tendons and ligaments are, in themselves, structures with important differences that are frequently cited and mistakenly observed. Tendons belong to muscle tissue despite being part of the connective tissue of a synovial joint as it connects a muscle to the bone it attaches to. A ligament, however, is a structure also made up of connective tissue, but it connects two bones and not a muscle and a bone, as the tendon does

(Dangelo & Fattine, 2007; Silva et al., 2020).

Synovial articulations also have menisci or discs that give them many mechanical benefits. The menisci are crescent-shaped structures that are located between two pieces of bone and have the function of more adequately distributing the loads that one piece of bone offers the other, better adaptation of the surface and fitting. The disks have similar functions, what differs between them is their shape, the latter being mentioned in an ellipse format (Dangelo & Fattine, 2007).

Ligamentous and musculotendinous injuries: A constant in the field of training

The connection between bones takes place through ligaments specialized in limiting the displacement between these connecting parts. One can easily observe injuries in which the limit of the ligament is exceeded, causing it to tear. In addition, there are ligaments that are located intracapsularly and others that are extracapsular, that is, the first are inside the joint capsule of the synovial joint, while the second are located outside, often attached to the fibrous membrane of the capsule (Dangelo & Fattine, 2007, Fernandes et al., 2021).

The tissue that makes up ligaments is called fibrous connective tissue. Its constitution is rich in typical cells of this type of tissue, the fibroblasts, with great synthesis of collagen and elastin. Its elasticity is reduced, with no possibility of contraction of this type of tissue (Dangelo & Fattine, 2007).

Since the elasticity of the fibrous connective tissue that make up ligaments in general is already physiologically reduced, excess overloads in their constitution easily result in ruptures and injuries (Dangelo & Fattine, 2007; Silva et al., 2020; Gonçalves et al., 2021).

Some exercises can lead to this damage suddenly or gradually. For example, the bench press is a typical movement performed by strength training practitioners. The amplitude of the eccentric phase of the exercise may influence the health of some shoulder ligaments, even more so under the conditions of overload that this exercise provides (Image 07). The shoulder is made up of muscles that form the cuff and extrinsic muscles related to movement of the humerus. The rotator cuff is made up of the supraspinatus, infraspinatus, subscapularis, and teres minor muscles. The tendons that make up the aforementioned muscles are similar in material and morphology to ligaments (Image 08). During an excessive eccentric phase of the bench press, the humerus ends up exceeding the limit of its joint axis, invading the space of the supraspinatus muscle, which is consequently pushed against the scapular accident called acromion. The long-term result will be progressive tearing of the supraspinatus muscle tendon (Dangelo & Fattine, 2007; Silva et al., 2020; Fernandes et al., 2021; Mendonça et al., 2021).

Image 07: Analysis of the eccentric movement of the pectoralis major muscle during the execution of the bench press exercise. (Source: personal files of Prof. Doc. Victor Fernandes).

However, sudden injuries can also affect tendons and ligaments. Imagine the following situation: a soccer player dominates the ball close to the center of the lawn. Your first decision is to move to a colleague on the same team, making the game more dynamic. However, he sees that everyone on his team is being well marked and, in order not to lose the ball in the position he is in, he decides to carry it with his feet forward. At that moment, an opponent observes the athlete's decision making and makes a stealthy attempt to recover the ball. Due to a slight delay on his body, he ends up missing the ball and hitting the athlete's ankle, who is immediately thrown to the ground in severe pain (Dangelo & Fattine, 2007; Fernandes et al., 2021; Mendonça et al., 2021).

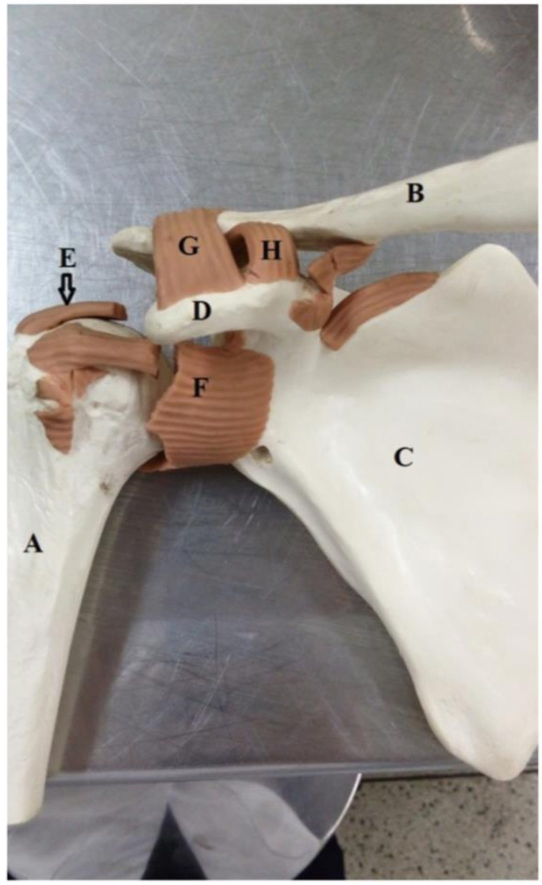

Image 08: Region of the rotator cuff, showing the scapula (anterior view), clavicle and humerus. The letter A indicates the humerus bone (intertubercular groove). The letter B indicates the clavicle. The letter C shows the subscapula fossa of the scapula (place of origin of the subscapularis muscle). The letter D indicates the coracoid process of the scapula. The letter E, being indicated by the arrow, presents the tendon of the supraspinatus muscle. The letter F stands for the subscapularis muscle. The letter G and H indicate the coracoclavicular ligament (trapezoid ligament H, conoid ligament G). (Source: personal archive of Prof. Doc. Victor Fernandes).

In addition to the fact that the tissue that makes up the ligaments is of low extensibility, other aspects also contribute to musculotendinous and ligament injuries, among them the characteristics of the joint. If you look closely at two synovial joints, you will see that both have their bones with articular cartilage surrounding the region that is internalized in the joint capsule, you will also see that this capsule has its membranes (both fibrous and serous) well organized and with its functions, which have already been presented in this text, well defined. However, some joints have higher injury rates than others. If you haven't noticed yet, search your memory for the number of students or clients they have who complain of shoulder pain. Now compare with the number of customers complaining of hip pain. Substantially lower the number of hip pains, isn't it? Well, of course, this may not be an absolute truth, given that the number of injuries to the lower limbs has been growing, mainly due to overweight (Dangelo & Fattine, 2007; Silva et al., 2020; Fernandes et al., 2021; Mendonça et al., 2021).

Shoulder: A synovial joint that must be remembered. In view of the importance that this diarthrosic joint assumes in the practice of physical exercises, mainly in the context of this material, resisted. It will be discussed and extensively studied in the following pages. It is recommended that you always make use of an anatomy atlas to accompany your reading, since you will be able to verify the structures mentioned in loco, even if some images have been developed for this purpose.

The shoulder joint is of great importance in sports and sports movements, since through it the connection between the axial and appendicular skeleton takes place. The shoulder is a constitution of structures of the upper limb, precisely the arm, and the scapular girdle. In this way, the bone relationships of the shoulder must be understood, so that the progression to the other structures can be made (Image 08).

The bones that make up the shoulder girdle are two, the clavicle and the scapula. The first of these connects to the sternum, at the level of the manubrium, precisely at the clavicular notch, thus establishing proximal-medial contact with the axial skeleton and distal-lateral contact with the scapula. Morphologically, these bones can be classified as laminar, for the scapula, and long, for the clavicle. This classification is due to the geometric aspects that these bones have, in addition to large faces for muscle attachment, in the case of the scapula (Dangelo & Fattine, 2007; Mendonça et al., 2021).

The topographic anatomy of the clavicle shows us a proximal region, which maintains contact with the steno bone, called the sternal end, and diametrically opposite to this, the acromial end can be seen (Dangelo & Fattine, 2007). The superior and inferior surfaces of the clavicle can be seen, both of which allow the fixation of important muscles, namely:

- ✓ Superior face (anterior region of the bone): deltoid muscle (near the acromial extremity); pectoralis major muscle (clavicular head of this muscle, close to the sternal end); sternocleidomastoid muscle (also close to the sternal end, just above the attachment of origin of the pectoralis major muscle);
- ✓ Upper face (posterior region): trapezius muscle (distal attachment or insertion);
- ✓ Lower face (anterior region): the continuity of the origin of the deltoid muscle is verified, as mentioned in the upper face, anterior region and the pectoralis major muscle. Pay attention to the fact that both muscles cover almost the entire perimeter of the upper and lower faces of the clavicle, in its anterior region, each close to its aforementioned extremity;
- ✓ Inferior face (posterior region): trapezoid and conoid ligament, at the acromial end. These ligaments form the coracoclavicular ligament, which is of great importance in stabilizing the clavicle in this area. In association with this, at the sternal extremity, there is the costoclavicular ligament (also on the inferior face and in the posterior region of the latter) (which connects the clavicle to the first rib).

The scapula, in turn, has more accidents and anatomical characteristics that will be mentioned below. The following regions of the scapula can be distinguished: superior margin, inferior angle, medial margin and lateral margin. Furthermore, two faces can be seen on the scapula, the anterior and posterior (Dangelo & Fattine, 2007; Silva et al., 2020).

On the superior border of the scapula, in a frontal view, that is, on the anterior surface. Two very important bone accidents can be seen, the scapular notch and the coracoid process. The scapular notch is connected to the coracoid process by the superior transverse ligament of the scapula, stabilizing this area in relation to the movement that the scapular girdle promotes. In a transitional area between the upper border and the notch of the scapula is the site of origin of the omohyoid muscle. This muscle originates on the scapula and inserts on the hyoid bone, located anteriorly in the neck (Dangelo & Fattine, 2007; Silva et al., 2020; Fernandes et al., 2021; Mendonça et al., 2021).

In the coracoid process of the scapula, the origin of the muscles coracobrachialis and the short head of the biceps brachii, both flexors of the elbow and located in the anterior compartment of the arm, is verified. Also located in the coracoid process is the insertion of the pectoralis minor muscle, which is very important in attaching the scapula to the thoracic cage (Fernandes et al., 2021; Mendonça et al., 2021).

Most of the anterior surface of the scapula is made up of the subscapular fossa, the site of origin of the subscapularis muscle (which forms part of the rotator cuff). In addition, the serratus anterior muscle fills the entire medial margin of the scapula, an important muscle involved in maintaining posture and adjusting the scapulae during many movements. The lateral border of the scapula has the glenoid cavity, the site of relationship with the humerus (arm bone) and very frequently injured in shoulder exercises. Also, on the lateral margin (anterior view), is the origin of the triceps brachii muscle (its long head) (Dangelo & Fattine, 2007).

In posterior view, the scapula shows some other formations and accidents. Passing obliquely in a superolateral direction, one can see the spine of the scapula, a site of important anatomical demarcation and attachment of muscles such as the trapezius and deltoid. At the end of the spine of the scapula is the acromion. This important reference point used in anthropometric assessments connects through the acroclavicular ligament with the clavicle and, through the coracoacromial ligament, with the coracoid process of the scapula itself (Dangelo & Fattine, 2007).

The region below the spine of the scapula is the site of origin for the infraspinatus muscle. In the region superior to this accident, the supraspinatus muscle originates in the supraspinatus fossa. Close to the inferior angle of the scapula, the teres major and latissimus dorsi muscles originate, while at the medial and lateral margins, the rhomboid minor, levator scapulae, rhomboid major, and triceps brachii (long head) muscles, respectively (Dangelo & Fattine, 2007).

The connection with the humerus, arm bone, is through the glenoid cavity of the scapula, which is located on the lateral margin of the laminar bone. This cavity has some structures of its own, which must be well understood.

Located in the center of the glenoid cavity is the articular cartilage of the scapula for constituting the synovial joint in conjunction with the humerus. Around this cartilage is the glenoid labrum, which in living beings is covered by the synovial membrane, the serous portion of the joint capsule. The function of the glenoid labrum, in a sense, is to contain movement of the humeral head within the glenoid cavity. However, injuries affect this structure (glenoid labrum) with great frequency. One of the most common injuries is tearing of the glenoid labrum, which derives from excessive local loads or repetitive movements, such as swimming, tennis or sports that involve a lot of shoulder movement. This injury can progress to local osteoarthritis, with greater damage to adjacent structures, such as the articular cartilage of the bones that make up this joint.

In an anterior view, still in the glenoid cavity, the subscapular bursa can be seen, located inferiorly to the apex of the coracoid process, in an area of transition between the glenoid cavity and the humerus. This structure, the subscapular bursa, assists in the mechanics of the shoulder, facilitating the fitting and movement of this joint. It is worth noting that it is still in front of the capsular ligaments.

As for the musculature present in the shoulder, the muscles with abduction and flexion functions stand out, with the deltoid active in both conditions, supraspinatus in abduction (mainly in the initial 15º of the movement) and the pectoralis major assisting in flexion. The deltoid and pectoralis major muscles are more superficial, while the supraspinatus is part of the muscle group that makes up the rotator cuff (Dangelo & Fattine, 2007).

The rotator cuff is characterized by the function of fixing the humeral head in the glenoid cavity, maintaining the integrity of the shoulder girdle. This structure includes the infraspinatus muscles (located in the infraspinatus fossa, inferior to the spine of the scapula), the subscapularis, located in the subscapular fossa, on the anterior face of the scapula, the teres minor muscle, which originates on the lateral margin of the scapula and it inserts below the greater tubercle of the humerus, and the supraspinatus, already mentioned above (Mendonça et al., 2021).

Rotator cuff injuries are very common in resistance training environments, this is due to the overload imposed on them, as well as the lack of prescribed exercises directed to this set of muscles. One of the most common is the tendonitis of the supra-spinal muscle. As image 09 can be seen that the supra-speech muscle has its origin in the supraspinal fossa in the portion above the spine of the scapula. Its insertion, however, occurs in the upper area of the larger tuber of the humerus. The supra-spinal is found under the acroMio, a process that clides the scapula's spine and maintains contact with the clavicle. In exercises such as the lateral elevation above the shoulder line, or bench press with exarcebated eccentric phase seeking to touch the bar in the sternum, in addition to the typical posterior handle, the supraspinal ends up scraping the acromion, precisely its tendon. Therefore, due to the friction caused by the bone in the fibrous connective tissue that inserts the muscle to the humerus, a tendonitis that can be classified at different stress levels develops. Level one The student has pain in the area, as well as annoying for abduction movements. Level two is already breaking some fibrous fiber fibers of the tendon and severe mobility lose. Level three, the most severe, the student lacks medical and possibly surgical intervention (Mendonça et al., 2021; Gonçalves et al., 2021).

Image 09: Side view of the left arm. Note that the letter A stands for the supraspinatus muscle. The origin of this muscle is in the supraspinatus fossa of the scapula. Its insertion, not seen in this image, occurs on the greater tubercle of the humerus. The letter B stands for the deltoid muscle. The letter C is the infraspinatus muscle. The letter D indicates the triceps brachii (lateral head), the letter E indicates the brachialis muscle (powerful elbow flexor). The letter F indicates the biceps brachii and the letters G and H indicate the brachioradialis and extensor carpi longus muscles. Source: personal files of Prof. Doc. Victor Fernandes.

Some exercises, as mentioned above, can induce this condition. Particular emphasis is placed on the posterior puller, which is often prescribed in gyms and sports centers and can potentiate the musculotendinous injury that affects the supraspinatus muscle (Fernandes et al., 2021).

Other muscles help move the shoulder. These muscles are classified as thoracoappendicular, given that they allow movement of the limbs so that they originate in the axial region, mainly in the thoracic area. In this way, the anterior thoracoappendicular muscles (image 10) and posterior are observed, the former being found in frontal view, while the latter in dorsal view (Dangelo & Fattine, 2007).

The anterior thoracoappendicular muscles are the pectoralis major, pectoralis minor, serratus anterior, and subclavius. It is noteworthy that the pectoralis major has double innervation, with the lateral and middle pectoral nerves being innervated. This condition characterizes a differentiated muscle activity to the pectoralis major depending on the angle at which the shoulder is. Therefore, in conditions where the shoulder is positioned at 90º, as in the image exercise, the most active region of the pectoralis major will be the sternocostal region. However, when the shoulder is at 60º, the clavicular area of the pectoralis major will be recruited more (Dangelo & Fattine, 2007).

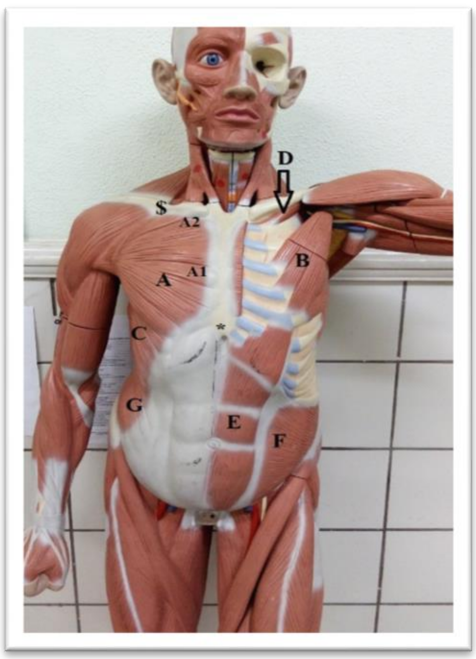

Image 10: Anterior view of the axial region showing the most prominent muscles and bone regions. The letter A indicates the muscle belly of the pectoralis major, while A1 indicates the sternocostal area and A2 the clavicular area. B indicates the pectoralis minor muscle and C, serratus anterior. The letter D is being pointed towards the subclavius muscle. The specimen was used to identify the rectus abdominis (E), internal oblique (F) and external (G) muscles. The * sign shows the xiphoid process of the sternum. The $ symbol shows the clavicle. Source: personal archives of Prof. Doc. Victor Fernandes.

Often in sports training environments, these variations are unconscious to the beginner practitioner or to the inexperienced professional without extensive knowledge of anatomy. However, attention to the movement must be well applied, considering that the movement with shoulders at 90º can cause muscle discomfort in the anterior region of the shoulder, due to overload of the muscles of the rotator cuff, precisely supraspinatus (Dangelo & Fattine, 2007).

Final considerations

Based on the analyzes and reflections carried out regarding the topic addressed, it is identified that the Physical Education professional lacks solid knowledge in the biological bases for an adequate prescription of training. However, the highest rate of injuries in the glenohumeral joint derives a lot from the wrong periodization of training, which advocates consecutive days that stimulate this body region. Injuries have a progressive association with microtraumas that can cause events of great proportions that must be taken into account, since they keep athletes and physical activity practitioners away for long periods.

References

1. Belozo, F. L., Pivetta, N., Fernandes, V. A., Belozo, R. S., de Paula, T. C., Katashima, C. K., ... & Silva, V. R. (2020). Functional mobility in older practitioners of Liang Gong exercise. *Journal of Rehabilitation Therapy*, *2*(2).
2. Mendonça, J. V., Netto, R. O. R. F., da Cruz, F. A., Galvão, D. A., Caldeira, E. J., Cunha, M. R., ... & Fernandes, V. A. R. (2020). Comparative Analysis Of The Glute Ham Developer Exercise. *Revista CPAQV–Centro de Pesquisas Avançadas em Qualidade de Vida| Vol*, *12*(3), 2.
3. Fernandes, V. A. R., Tirelli, J., Brito, G., D'Abronzo, F. H., Cunha, F., Pavan, V., Belozo, F. L., Caldeira, E. J., & Conte, M. (2020). Análise do perfil antropométrico e do nível de atividade física de escolares matriculados em período integral em comparação a escolares matriculados em período parcial de estudos. *Revista Brasileira de Prescrição e Fisiologia do Exercício - RBPFEX*, 14(90).

4. Pelegrina, T.A. et al. (2021). O Papel do personal trainer na prática de exercícios físicos. *Revista Pulsar*, 13(1).
5. Camargo, J.B.B. et al.(2020). Inactivity during COVID-19 Quarantine and its Effects in Strength and Functional Parameters in Elderly: a Case-Study, International Journal of Sports and Exercise Medicine, 6. DOI: 10.23937/2469-5718/1510180.
6. Cunha, F. B., Pomini, K. T., Plepis, A. M. D. G., Martins, V. D. C. A., Machado, E. G., de Moraes, R., ... & Cunha, M. R. D. (2021). In vivo biological behavior of polymer scaffolds of natural origin in the bone repair process. *Molecules*, *26*(6), 1598.
7. Santos, J.S. et al. (2021). Alterações morfológicas das vértebras lombares e sua associação com as neuropatias do membro inferiores, Revista Pulsar, 13(1).
8. Gonçalves, T. O., Monteiro, F., Cunha, M. R., & Fernandes, V. A. R. (2021). Effects Of Creatine Monohydrate Supplementation On Adipose, Musculoskeletal Tissue And Physical Performance Of Rattus Norvegicus. *Revista CPAQV–Centro de Pesquisas Avançadas em Qualidade de Vida,* 13(1).
9. Fernandes, V. A. R., de Andrade, T. N., da Cunha, M. R., Paulini, M., Iatecola, A., Inacio, M. F. C., ... & Machado, J. L. M. (2020). Matrizes poliméricas para a regeneração óssea. Revisão da literatura. *Revista Multidisciplinar da Saúde*, *2*(3), 42-53.
10. Fernandes, V. A. R., Col, L. O., Moura, E. G., de Matos, M. O., Caldeira, E. J., & Conte, M. (2018). Treinamento de força e seus efeitos sobre a área de secção transversa e perímetro celular de miócitos do gastrocnêmio de rattus novergicus. *RBNE-Revista Brasileira de Nutrição Esportiva*, *12*(73), 675-679.
11. Silva, T., Silva, C., Belozo, F. L., Conte, M., & Fernandes, V. A. R. (2020). Modificações antropométricas derivadas de uma periodização clássica no treinamento resistido. *Revista Multidisciplinar da Saúde*, *2*(2), 32-45.
12. Riesberg, L. A., Weed, S. A., McDonald, T. L., Eckerson, J. M., & Drescher, K. M. (2016). Beyond muscles: The untapped potential of creatine. *International immunopharmacology*, *37*, 31-42.