v. 5, n. 14, 2025

International Journal of Health Science

ANALYSIS OF THE MORPHOLOGICAL AND FUNCTIONAL CLASSIFICATION OF UPPER AND LOWER LIMB JOINTS: A LITERATURE REVIEW

Acceptance date: 14/03/2025

Wesley Douglas de Melo Felix
Medicine Afya Jaboatão

Willyan Douglas de Melo Felix
Doctor at Afya Jaboatão

Nívea Gabriela Braga e Silva
Medicine Afya Jaboatão

Helena Azevedo Pfeuffer Wulff
Medicine Afya Jaboatão

Livya Tavares Cruz Figueiredo
Afya Jaboatão Medicine

Ingrid Susany Miranda Martins
Medicine Afya Jaboatão

Letícia Dall'agnol Costa
Medicine Afya Jaboatão

Rayana Priscilla dos Santos
Medicine Afya Jaboatão

Lucas Ferreira de Lucena
Doctor at Afya Jaboatão

Diego Felliphe Pessoa Reis
Doctor at Afya Jaboatão

Clécio da Silva Oliveira
Doctor from the Federal University of Pernambuco - UFPE

Elenilson Pereira dos Santos
Doctor from the Federal University of the State of Rio de Janeiro - Unirio

Rita de Cássia Hoffmann Leão
MD, University of Pernambuco, CREMEPE Councillor and co-supervisor

Ricardo Ferreira dos Santos Júnior
MD from the University of Pernambuco, lecturer at Afya Jaboatão and advisor

Abstract: INTRODUCTION: A joint is defined as the place where there is a connection between two or more bones, or between cartilage and bone. It has its own individual function and shape, which is what will allow it to move or not. **OBJECTIVE: To** address the morphological and functional issues of the joints of both the upper limbs (MMSS) and lower limbs (MMII). **Methods:** This is an integrative literature review based on the guiding question: "What is the morphological and functional classification of the joints of the upper and lower limbs?". The descriptors "joint", "morphology", "functionality" and "anatomy" were used to locate the articles in the databases. Virtual and physical books were included, as well as articles in Portuguese and English published from 2014-2021 and letter-type studies were excluded. The snowball strategy was used to capture new evidence. **DISCUSSION:** The upper limbs are characterized by being prehensile and have four main segments. The functional and biomechanical aspects of the upper limb and lower limb joints include the physiology of the joint itself, as well as anatomy, muscle physiology, mechanics and kinesiology. **CONCLUSION:** This study analyzed that the joints are responsible for numerous movements performed by the axial and appendicular skeleton. The main movements include flexion, extension, adduction, abduction, internal rotation and external rotation, which gradually contribute to the functions needed throughout life when it comes to the human body.
Keywords: Anatomy. Joint. Morphology.

INTRODUCTION

A joint is defined as the place where there is a connection between two or more bones, or between cartilage and bone. It has its own individual function and shape, which is what will allow it to move or not. In addition, it can be classified into three parts, varying according to the material that makes it up, as well

as the way in which the bones articulate. They can therefore be identified as synovial, fibrous and cartilaginous.

In view of the above, it is of the utmost importance to have knowledge of the joints and their morphology associated with their functionality. This will make it easier to understand when there is a joint dysfunction. It also makes it easier to manage if there are any morphological or functional changes. In other words, the prognosis of the patient, who is affected by the pathology associated with the joint, will be increasingly improved, leading to a better quality of life.

MATERIALS AND METHODS

This is an integrative literature review. The research question was defined as: "What is the morphological and functional classification of the joints of the upper limbs and lower limbs?". The review was conducted in the databases of the virtual and physical library of Faculdade Tiradentes using physical books and virtual books. The descriptors used were "anatomy", "joint", "morphology" and "functionality" combined using the logical operator "AND".

The inclusion criteria for the research were: 1- Books from 2014-2021; 2-Observational studies, case reports; 3-Books published in the year 2014-2021; 4- Books published in English, Spanish or Portuguese. The following were excluded: 1- Books repeated in a database; 2- Letters to the reader or editorial comments; 3- Books that did not address the subject in its entirety.

At the initial stage, a search was made and then a selection was made by reading in general to analyze whether the study/book would be included or not. In addition, those that were included were critically read. This reduced the risk of methodological bias.

Thus, during construction, each joint that makes up both the upper and lower limbs was shown in detail, and finally, some examples of joint dysfunction were presented.

RESULTS AND DISCUSSION

Joints are classified as the connection of at least two hardened segments, most of which can be identified as bones and cartilage. The shape and function of each joint is very individual, and it can have movement or not, for example. They are classified into a large group divided into three parts, according to the material present or how the bones that end up articulating are joined together. They are identified and separated as synovial, cartilaginous and fibrous (MOORE; DALLEY, 2019)

Fibrous joints are joined by fibrous tissue. The movement of this joint depends, for the most part, on the length of the fiber that joins the bones that articulate there. Within this classification, we find syndesmosis, a fibrous joint that uses a sheet of fibrous tissue to join the bones. This lamina can be a fibrous membrane or a ligament, which ends up reducing mobility in this type of joint. In addition, we can also find gonfosis, a fibrous joint found in teeth (MOORE; DALLEY, 2019).

Cartilaginous joints connect structures through hyaline cartilage or fibrocartilage. They are divided into primary and secondary aspects. Primary joints, also called synchondroses, are generally temporary and allow bone to grow in length. Secondary joints, or symphyses, are joints joined by fibrocartilage, which are not very mobile and are strong. Synovial joints, which allow greater movement between bones, are the most common type of joint and ensure locomotion. The fibrocartilaginous articular discs and menisci are distinct characteristics that can appear in this type of joint (MOORE; DALLEY, 2019).

In addition to all of the above, it is very important to talk about the vascularization of the joints. The joint arteries are responsible for irrigating the joints. Along with these arteries, we find the joint veins, which are also located in the joint capsule and complete this innervation (MOORE; DALLEY, 2019).

MORPHOLOGICAL ASPECTS OF THE JOINTS

UPPER LIMBS

The upper limbs are characterized by being prehensile and have four main segments. Shoulder, which is the most proximal segment; arm, the first free segment; forearm, the longest segment; and hand, the most distal part of the upper limb (MOORE; DALLEY, 2019).

The shoulder is responsible for the mobility and structural stabilization of the upper limb when performing specific movements. The only attachment of the upper limb to the axial skeleton is in the region of the manubrium through the sternoclavicular joint. The scapula, clavicle and manubrium articulate with each other and form an incomplete cingulum, with no posterior connection. In addition, the clavicle is the S-shaped bone that connects directly with the manubrium via the sternoclavicular joint. It also articulates laterally with the scapula via the acromioclavicular joint. The scapula is a triangular bone that provides stability for the shoulder joint and support for the cingulum muscles of the upper limb (MOORE; DALLEY, 2019; WASCHKE, 2018).

The arm is the first segment of the upper limb that is mobile and independent of the trunk. It extends from the shoulder to the elbow and consists of just one bone, the humerus. As the largest bone in the upper limb, it articulates proximally with the scapula in the glenohumeral joint, also known as the shoulder joint. The head of the humerus is larger when compared to the glenoid cavity of the scapula, so the glenoid lip is essential in increasing the joint fit, favoring a greater range of movement (BEHNKE, 2015; WASCHKE, 2018)

In the distal region, the humerus also articulates with the radius through the humeroradial joint, one of the three joints that make up the elbow joint. The elbow is a region between the arm and the forearm, made up of three joints: ulnar humerus, humeroradial and proximal radioulnar; all three joints are covered by the same capsule and are responsible for the hinge movement (ginglimo) performed by the elbow. In addition, the forearm extends from the elbow to the wrist, is considered the distal joint support unit of the upper limb and contains two bones, the radius and ulna. The bones of the forearm are joined by an interosseous membrane that allows pronation and supination (BEHNKE, 2015; MOORE; DALLEY, 2019; WASCHKE, 2018).

The hand is the most distal part of the upper limb. It is responsible for grasping, pinching, precision handling and free movement. The hand is subdivided into three segments: carpus, metacarpus and phalanges. The carpus is made up of 8 muscles, separated by rows; the proximal row contains the scaphoid, semilunar, pyramidal and pisiform muscles; the distal row contains the trapezius, trapezoid, capitate and hamate muscles. The phalanges, like the metacarpal, are numbered from 1 to 5 from the radial to the ulnar end. In the hand, the joint groups are: radiocarpal, mediocarpal, intercarpal, carpometacarpal, intermetacarpal, metacarpophalangeal and interphalangeal joints of the hand (MOORE; DALLEY, 2019).

LOWER LIMBS

Locomotion, support and maintaining balance are specializations of the lower limbs. They are attached to the body via the lower limb girdle, which is made up of the sacrum and the hip bones, which are joined by the pubic symphysis. The lower limbs are divided into six parts, namely the gluteal region, which includes the hip region and the buttocks, the thigh region, the knee, the crural region, the talocrural region and the foot region (HOUGLUM; BERTOLI, 2014).

The joints of this segment are divided into the cingulum joints of the lower limbs, which include the lumbosacral, sacroiliac and pubic symphysis joints, the hip joint, the knee joint, the tibiofibular joints, the talocrural joints and the foot joints. The cingulum of the lower limbs is characterized by being a ring formed by the union of three bones in adults, as mentioned above. Through it, the spine is connected to the two femurs, the weight is transferred from the axial skeleton to the lower appendicular skeleton and the local viscera receive protection (HOUGLUM; BERTOLI, 2014).

The sacroiliac joints are strong and firm, they support the body and are formed by two joints, the anterior one being an anterior synovial joint and the posterior one being a syndesmosis. This joint has restricted mobility, with slight sliding and rotational movements, reflecting its transmission of weight to the hip bones, which is one of its main functions. In addition, we have the pubic symphysis, a joint classified as secondary cartilaginous, resulting from the junction of the pubic bodies in the median plane (HOUGLUM; BERTOLI, 2014).

The hip region is an area of weight transmission, where it passes the weight of the axial skeleton to the lower limbs. This occurs through the hip musculature, which is made up of resistant musculature, causing this transmission from the axial region to the structures of the axial skeleton, such as the femur. Furthermore, the region between the head of the femur and the acetabulum is known as the hip joint. This joint is more stable than the shoulder joint, which was discussed above. It performs spheroid-type movements, encompassing flexion and extension, abduction and adduction, for example (HOUGLUM; BERTOLI, 2014).

Another part that makes up the lower limbs is the knee, which is classified as a synovial joint of the gymnastic type, where flexion and extension movements are possible. In addition, there is the hinge movement, which occurs in conjunction with rolling, sliding and rotation around a vertical axis. The knee joint is the junction of three joints: the lateral and medial femorotibial joints and the intermediate patellofemoral joint, which is located between the patella and the femur. The stability of this joint depends on the strength and conduct of the surrounding muscles. The quadriceps femoris muscle is very important in this process, as are the tendons that connect the fibula and tibia. Knee flexion is performed by the patellofemoral and patellofemoral joints, while extension is also performed by these joints. Medial and lateral rotation depends on the femorotibial joint when the knee is flexed (MOORE; DALLEY, 2019).

Another extremely important joint in the lower limbs is the tibiofibular joint, as the tibiofibular syndesmosis joins the tibia and fibula superiorly and inferiorly, respectively. The tibiofibular joint is characterized by being a flat synovial joint, while the tibiofibular syndesmosis is classified as a compound fibrous joint. In addition to the above, the talocrural joint is also part of the lower limb group and is classified as the ankle joint. It is characterized as a synovial joint of the gingival type, which is located between the distal ends of the tibia and fibula and the high part of the talus (MOORE; DALLEY, 2019).

The tarsal bones, metatarsals and phalanges are involved in the foot joint. The talocalcaneal joint and the transverse tarsal joint are the joints that make up the intertasals. Eversion and inversion of the foot are the movements performed by this joint. The talocalcaneal joint is a flat synovial joint, the talocalcaneonavicular joint is classified as a synovial joint and the talonavicular part is a spheroid joint, responsible for movements such as sliding and rotation. The calcaneocuboid joint is a flat synovial joint that performs movements such as inversion and eversion of the foot. The cuneonavicular joint is a flat synovial joint,

responsible for small movements, as well as the intermetatarsal and tarsometatarsal joints, which involve sliding movements (MOORE; DALLEY, 2019).

Finally, the metatarsophalangeal joints are ellipsoid synovial joints, which are responsible for flexion, extension, abduction, adduction and circling movements performed by the foot. Meanwhile, the interphalangeal joints are synovial joints of the gymnoglossus type that perform flexion and extension movements (MOORE; DALLEY, 2019).

BIOMECHANICAL AND FUNCTIONAL ASPECTS

The functional and biomechanical aspects of the upper limb and lower limb joints cover the physiology of the joint itself, as well as anatomy, muscle physiology, mechanics and kinesiology. Its ultimate purpose is to provide support for the gestures and postures of a healthy person, as well as to make common dysfunctions and pathologies understandable, deducing the most appropriate and adapted therapeutic approaches for each joint (DUFOUR; PILLU, 2016).

The biomechanics of the joints of the upper limbs and lower limbs brings with it mechanical principles and laws that are properly applied to human beings, with regard to the mechanical aspects of bones and muscles, as well as blood, lymph, cerebrospinal fluid, known as fluid mechanics, and also gases, the so-called ventilatory mechanics (DUFOUR; PILLU, 2016).

UPPER LIMBS

The upper limbs are part of the appendicular skeleton and are interconnected to the axial skeleton through the scapular cingulum, also known as the scapular girdle. This cingulum, which is formed by the scapula and clavicle, is responsible for connecting the arm, forearm and hand to the axial skeleton, as well as allowing a wide range of movement. The joints that make up the upper limbs are: shoulder, elbow, wrist and hand (PORTELA, 2016).

The shoulder joint is a suspended proximal joint of the upper limb that extends from the upper and lateral part of the thorax to the upper part of the thorax. It moves in all three planes and is made up of the bones: humerus, scapula and clavicle, as well as sixteen muscles and ligaments that ensure the joint's stability (PORTELA, 2016). It is made up of a complex of 5 joints: acromioclavicular, sternoclavicular, glenohumeral, scapulothoracic-serratus, which are characterized as authentic joints, and the subdeltoid, also known as the false Sèze joint, which is characterized by its functional aspect (DUFOUR, PILLU, 2016).

The scapulothoracic-brachial complex is part of the mechanical link between the movements of the arm and those of the trunk and scapula. Knowing that grasping is the main objective of the upper limb, this in turn is initiated through the shoulder joint, which guarantees the arm's sense of space (DUFOUR, PILLU, 2016).

The sternoclavicular joint has the function of connecting the manubrium of the sternum to the proximal end of the clavicle, as well as to the cartilage of the first rib, forming a synovial saddle joint with three degrees of freedom. There is a cartilaginous disc between the two faces of these bones, which reduces the incongruity of the surfaces, allowing for a better and greater likelihood of rotational movement for both the clavicle and the scapula (PORTELA, 2016).

The acromioclavicular joint is a small, irregular, diarthrodial synovial joint, which allows only limited movement and connects the acromial process of the scapula to the clavicle. The glenohumeral joint is a sphere-shaped joint, which has a shallow, piriform glenoid fossa, thus allowing a wide freedom of movement, reaching maximum angles, due to the interaction of the articular cingulum muscles with the shoulder complex (PORTELA, 2016).

The shoulder has great mobility due to the fact that its joint is spatial, and even more important when compared to its counterpart in the lower limb. One of its uses is throwing objects (DUFOUR, PILLU, 2016). The shoulder complex performs the following movements: flexion and hyperflexion, extension and hyperextension, adduction, abduction, medial rotation, lateral rotation and circumduction (PORTELA, 2016).

The elbow is an intermediate joint of the upper limb and extends from the lower epiphysis of the humerus to the upper epiphyses of the radius and ulna (bones of the forearm) (DUFOUR, PILLU, 2016). It is considered a simple hinge joint, but is classified as a trochlear joint, made up of three joints: humeroulnar, humeroradial and proximal radioulnar (HALL, 2021). The three joints that make it up are stabilized by the anterior and posterior radial collateral ligaments, as well as by the ulnar collateral, within the joint capsule, ensuring the stability of the elbow (PORTELA, 2016).

The humeroulnar joint (the trochlea of the humerus articulates with the trochlear fossa of the ulna) is the so-called hinge joint of the elbow. It performs flexion and extension, which are the main movements of this joint. It's worth noting that some people hyperextend the elbow when permitted. The humeroradial joint is located laterally to the humeroulnar joint (the section of the humerus that articulates with the proximal end of the radius) and is flat, but limits movement to the sagittal plane. The proximal radioulnar joint (annular ligament connecting the head of the radius to the radial recess of the ulna) is pivotal, meaning that when the forearm is prone and supine, the radius rolls medially and laterally over the ulna (HALL, 2021).

The wrist is made up of eight bones that are organized into two rows, as well as twenty radiocarpal, intercarpal and carpometacarpal joints; twenty-six intercarpal ligaments and more than six extensions of the fibrocartilaginous triangle complex, and is also responsible for almost 90% of all upper limb functions (VASCONCELOS *et al.*, 2019). The proximal region of the wrist is made up of the radius and ulna bones and the distal region of the wrist is made up of the semilunar, scaphoid, pyramidal and pisiform bones (these make up the 8 rows). The distal row is made up of the capitate, hamate, trapezium and trapezoid bones (HALL, 2021).

Most wrist movements take place in the radiocarpal joint (radius and the three carpal bones). This is a chondyloid joint in which the radius articulates with the semilunar, pyramidal and scaphoid bones, allowing flexion, extension and hyperextension movements in the sagittal plane and ulnar and radial deviation movements in the frontal plane. As for the intercarpal joints, they provide gliding that does little to help the wrist move (HALL, 2021).

Around the wrist is a fascia made up of very strong fibrous bundles known as retinacula. The retinacula form protective tunnels for the tendons, blood vessels and nerves, as this is where they pass through. The retinaculum is divided into flexor and extensor: extensor - is in the dorsal region of the wrist and forms the tunnel for the extrinsic extensor tendons; the flexors protect the extrinsic flexors, as well as the median nerve, which crosses the palmar side of the wrist (HALL, 2021).

The movements of the wrist allow the lateral deviation of the hand at the wrist to take place, and this occurs through the integrated action of the extensor and flexor muscles. The ulnar flexor of the carpus (performs wrist flexion and adduction) and the ulnar extensor of the carpus (performs wrist extension and adduction), but together they cause ulnar deviation; meanwhile, the radial flexor of the carpus (performs wrist flexion and abduction) together with the long and short radial extensors of the carpus when contracting, produce

radial deviation (HALL, 2021). In addition to these movements, the wrist also performs circumduction, which is done through the congruence of flexion and abduction; extension, hyperextension and adduction, performed sequentially (PORTELA, 2016).

The hand has an enormous capacity to carry out countless movements, which requires a range of joints. The joints of the hand are: carpometacarpal, intermetacarpal, metacarpophalangeal and interphalangeal. The fingers or chirodactyls are called digits from 01 to 05, the thumb being the first. The carpometacarpal joints are considered to be sliding joints, with the exception of the thumb and the trapezius joint with the first metacarpal, which is a classic saddle joint. It's worth noting that all these joints are surrounded by joint capsules, which are reinforced by the dorsal, interosseous and palmar carpometacarpal ligaments. The intermetacarpal joints also share these joint capsules (HALL, 2021).

The metacarpophalangeal joints are ellipsoid joints (between the distal parts of the metacarpals and the proximal ends of the phalanges), which form "knots" in the fingers (VASCONCELOS *et al.*, 2019). These joints make the movements of adduction and abduction, flexion and extension and circumduction of the fingers 02 to 05 occur. Because the articular surfaces of the first finger (thumb) of this joint are relatively flat, they allow the movement to function as a hinge, which only allows flexion and extension movements. Therefore, when in the locked position on the thumb and the other fingers, the movements of opposition and total flexion are performed, respectively (HALL, 2021).

The interphalangeal joints perform flexion and extension movements, although some individuals can perform slight hyperextension movements (VASCONCELOS *et al.*, 2019). They are classic gymnastic joints (HALL, 2021).

LOWER LIMBS

The lower limbs are part of the appendicular skeleton connected to the axial skeleton by the pelvic girdle, which is formed by two iliac bones (hip bones), made up of three bones: ilium, ischium and pubis. The pelvic girdle articulates with the sacrum, forming the sacroiliac joint, which allows practically imperceptible movements. It is worth noting that the sacrum is not part of the lower limb (pelvis), despite its close anatomical connection with the pelvic bones (PORTELA, 2016). The hip joint is a spheroid joint, formed by the attachment of the head of the femur to the acetabulum of the hip bone, with a concave shape providing a deep attachment and three planes of movement.

The acetabulum is covered by hyaline articular cartilage, which is thicker in its vicinity, as this is where the acetabular lip is located, which favors the balance and stability of the joint, even though it has several ligaments that present resistance and therefore interfere with the movements of this joint. There is the transverse ligament, which acts as a bridge over the acetabular notch, structuring the circumference of the acetabulum; the ligament of the head of the femur, whose function is to maintain the head of the femur in the lower region of the acetabulum, stabilizing it (PORTELA, 2016).

Three ligaments are specifically related to each of the pelvic bones that make up the acetabulum. The iliofemoral ligament, known as the Y ligament, characterized by the presence of very strong fibres, which have the function of promoting extension and rotation movements. The pubofemoral ligament, which controls abduction and helps develop extension and lateral rotation movements. The ischiofemoral ligament is characterized by controlling medial rotation and abduction (PORTELA, 2016).

The proximal tibiofibular joint is a flat synovial joint located between the articular surface of the head of the fibula and the fibular articular surface of the tibia, covered by

cartilage and joined by the joint capsule and the anterior and posterior ligament. It allows simple sliding movements (PORTELA, 2016). When it is presented distally, it is characterized by being a syndesmosis-type joint formed between the articular surface of the lateral malleolus and the fibular notch of the tibia. There are no major movements in this joint and the anterior, posterior, inferior transverse and interosseous ligaments circulate in it and firmly join the distal ends of these two bones (NETTER, 2018).

The joints of the foot are divided into the ankle joint, which acts as a link between the foot and the leg, and the subtalar and mediotarsal joints, which promote movement within the foot (HALL, 2021). The ankle is a structure made up of the joint between the talus and the malleoli of the tibia and fibula, and is characterized as a hinge joint. The ligaments that join this joint are: anterior tibiofibular ligament, posterior tibiofibular ligament, deltoid ligament, anterior talofibular ligament, posterior talofibular ligament, transverse ligament, interosseous ligament, calcaneofibular ligament and lateral collateral ligament. (NETTER, 2018) The talus-calcaneal joint is a combined tropoid-spheroid synovial joint, which allows supination and pronation movements (PORTELA, 2016).

The tarsometatarsal joints are formed by the first, second and third cuneiform bones, as well as the cuboid, which articulate with the bases of the metatarsal bones. This joint is of the flat synovial type (PORTELA, 2016), allowing sliding movements. However, the metatarsophalangeal joints are spheroid synovial joints with limited function. They are of the synovial type condylar, and are formed through the union of the metatarsal head with the shallow cavities of the ends of the first phalanges of the toes, being fixed by the collateral and plantar ligaments (NETTER, 2018). Finally, there are the interphalangeal joints, which are synovial in nature. Each one has two collateral ligaments and a plantar ligament. These help with gait movement and stability (PORTELA, 2016).

CONCLUSION

Based on most of the studies and books that were used to build this research, it was possible to analyze that the joints, both of the upper limbs and lower limbs, have important functions for the human anatomy. Furthermore, it can be inferred that when there is a component that causes a change in the structure, whether due to inflammation, injury, rupture or others, it is clear that the limb and/or associated structure is malfunctioning. Therefore, the proper functioning of the joints of the human body favors homeostasis and life.

REFERENCES

BEHNKE, Robert S. **Anatomia do movimento**. Artmed: Grupo A, 2015.

HALL, Susan J. **Biomecânica Básica**, 8ª ed. Rio de Janeiro: Editora Guanabara Koogan S.A: Grupo GEN, 2021.

HOUGLUM, Peggy A.; BERTOLI, Dolores B. **Cinesiologia Clínica de Brunnstrom,** 6ª ed. São Paulo: Manole, 2014.

MOORE, Keith L.; DALLEY, Arthur F.; AGUR, Anne M R. **Anatomia Orientada para Clínica**, 8ª ed. Editora Guanabara Koogan S.A: Grupo GEN, 2018.

PORTELA, Joana P. **Cinesiologia**, 1ª ed. Sobral, 2016.

VASCONCELOS, Gabriel S. et al. **Traumato-ortopédico funcional I**. Porto Alegre: SAGAH, 2019**.**

WASCHKE, Jens. **Sobotta Anatomia Clínica**. Elsevier Editora Ltda: Grupo GEN, 2018.