ANATOMY OF THE SHOULDER AND ARM MUSCLES OF *Cebus libidinosus*

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ABSTRACT

Cebus are a very cognitive species. They have expansive motor abilities, demonstrate a high level of proficiency in using tools to obtain food; and play, using thoracic members. Our objective in this work is to study the shoulder and arm muscles of *Cebus genus*, comparing the findings with the literature data on humans, chimpanzees and baboons, and assume these aspects are associated with behavioral characteristics. We conclude that the shoulder and arm muscles of *Cebus*, in general terms, are more similar to baboons, perhaps due to the quadruped behavior exhibited in these animals. The conventional term "hand abilities" in primates, specifically in *Cebus*, originate in motor abilities, generally, from thoracic members. They are controlled by a high encephalic index, and not by specific motor abilities from the intrinsic muscles of the hand and forearm which act on the hand.

Key words: Capuchin monkey, muscles, primates, thoracic member

INTRODUCTION

Lately, many studies about the *Cebus libidinosus* [30] have been performed on the encephalic vessels [12,21,32,33,34], the submandibular gland vessels [22], anatomical superior members [3,4,5], the cortical physiology [18], the behavioral and tool use [1,2,6,10,14,17,29,41], encephalic index [26] and memory [37]. These studies also show that *Cebus libidinosus* [30] are capable of using tools to obtain food, and exhibit playfulness. These aspects are observed in captivity [13,31], as well as in their natural habitat environment. [6,29].

The comparative anatomical studies between *Cebus* and chimpanzees confirm this data of evolutionary convergence [3,4,5] concerning the muscles, nerves and vessels of thoracic members.

The main evolutionary characteristics acquired by hominids were the erect posture and bipedal locomotion on the ground, substituting brachiation (hand used for locomotion on the trees). There are evolutionary and morphologic similarities between *Cebus* and humans [11,15,16], as well as noted similarities in bipedal nature [8].

The survival and arborous behavior of the human primate indicates morphological similarities between these species and *Cebus*. The anatomical study provides the base for verification of motor abilities of primate species; considering the number of muscles, and the division and individualization of a muscular body that is inserted into the osseous portion [3].

MATERIAL AND METHODS

Samples – Eight specimens of the *Cebus libidinosus* (capuchin monkey) were used for this project. Healthy adults, differing in age, were studied in a group comprised of seven males and one female. The average body weighed between one and three kilograms. Physical appearance ranged from black hair, various brown shades to the more common dark brown. The animals were donated by the Brazilian Institute of Environment and Natural Resources (IBAMA), from the city of Sete Lagoas, in the state of Minas Gerais, in 1970;

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and were deposited in the anatomical collection of the Federal University of Uberlândia (UFU) and Federal University of Goiás (UFG). This work was previously approved by the ethics committee of UFG (Veterinary Medicine).

Preparation of animals for dissection – The dead animals were rasped with steel. The animals received an injection of latex 601-A (Dupot), mixed with red colorant diluted in ammonium hydroxide, in the abdominal part of the aorta. The bodies were submerged in room temperature water for 10-12 hours; and received an injection by femoral vein, of approximately 10% formaldehyde mixed with 5% glycerin, for fixation. The animals were preserved in 10% formaldehyde, in a closed opaque box.

Dissection and documentation – The dissection of the arm and shoulder were performed with emphasis on the muscles, and documented with a digital camera (Sony, 4.1 mega pixels). The muscle denominations were based on descriptions of humans and other primates. The collected data was analyzed and compared with a decrypted human model.

The arm and shoulder muscles were dissected and analyzed with the origin and insertion criteria, because the enervation of muscles was related [3], and the studies of the vessels of the arm and shoulder were also carried out (in print). The muscle origin was considered according to the aspects of (1) fixed point of movement and (2) near to median axis. In these particulars, the insertion was also considered by two aspects: (1) the move point of locomotion and (2) the distal region from the median axis of capuchin monkey. The results are synthesized in Table 1.

The biceps braquial muscle (Figs 3,4) has two origins. The short head of the biceps muscle and *coracobraquial* muscle have the same origin, in the *coracoid* process of the scapula, by the common tendon. The lateral portion arises from the supraglenoid tuberosity and its tendon descends in the intertubercular groove, enclosed by the articular capsule of the shoulder. The insertion of the *brachialis* muscle is doubled: one occurs on the postero-medial surface of tuberosity of the radio, and the other gives off an aponeurosis for the superficial fascia on the proximal antero-lateral portion of the forearm. This muscle is fusiform and is located in an anterior area of the arm.

The *coracobrachialis* muscle (Fig. 1) comes together with the short head of the *biceps brachii* muscle. It is inserted in the middle third part of the humerus, on the antero-medial surface of this bone. In this way, this muscle divides muscular fibers, with the short head of the *biceps brachii*. It has a laminar form, and is located at the proximal and antero-medial portion of the arm.

The *pectoralis minor* muscle stems from the lateral border of the sternum, and is attached in the area between the second and fifth rib. It is inserted by a thick tendon at the greater tubercle of the humerus. It has a fan shape, and is located under the *pectoralis major* muscle.

The *pectoralis major* muscle (Fig. 3) originates from all lateral borders of the sternum bone, with the medial portion attached along two-thirds of the clavicle, and the anterior portion lamina of the aponeurosis of the *rectus abdominis* muscle. This muscle is inserted at the crests of the greater tubercle and intertubercular lips, in the proximal third part of the humerus. It has a triangular shape, and forms the anterior border of the armpit. It is the most superficial muscular layer of the anterior thoracic wall.

The *pectoralis abdominis* muscle (Fig. 3) stems from the lateral border of the rectus sheath, and is more caudal than the origin of the pectoralis minor muscle. It is inserted at the greater turbercle of the humerus bone, in the medial portion, as a common aponeurosis with the *pectoralis minor*. It is located caudally to the *pectoralis major*, and is flat and thin.

The *brachialis* muscle (Fig. 1) originates immediately distal to the *deltoid* muscle's insertion, at the *deltoid* tuberosity of the humerus; in the distal two-thirds part of the antero-lateral surface of this bone. Some muscular fibers of the *deltoid* are inserted in the proximal portion of the *brachialis* muscle. The distal portion of the *brachialis* muscle crosses the radius bone, from the lateral portion to the medial portion, and is inserted in the proximal and medial surface at the ulnar tuberosity. The *brachialis* is located deeply in the arm, below the biceps brachii muscle, in the distal half portion. It has a pyramidal form.

The *anconious* muscle stems from the posterior part of the lateral epicondyle of the humerus, and is inserted in the lateral portion of the olecranon. It has a triangular shape.

The *triceps brachii* muscle (Figs. 1,2) originates as three heads: (1) the long head originates through the aponeurosis, like a fan, that extends from aponeurosis, with the *teres major* muscle, to the *supraspinatus* and supraglenoid tuberosity of the scapula; (2) the lateral head stems from the proximal third part of the humerus on its postero-lateral surface. (3) Finally, the medial head derives from the entire postero-medial surface

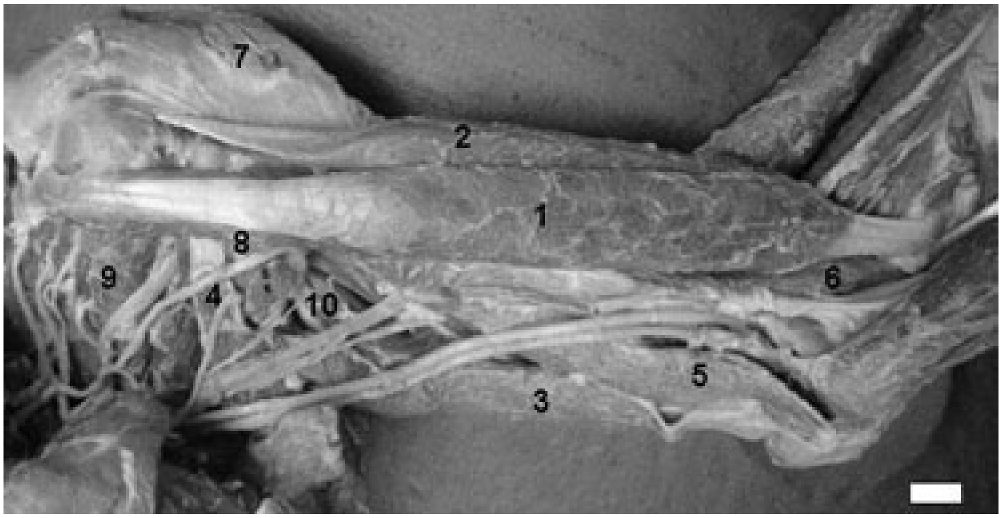

Figure 1. Antero-medial view of the *Cebus*' arm. 1. Medial head of the biceps brachii muscle; 2. lateral head of the biceps brachii muscle; 3. dorso-olecranon muscle[3]; 4. insertion's tendon of the latissimus dorsi muscle; 5. medial head of the triceps brachii muscle; 6. brachialis muscle; 7. *deltoid* muscle; 8. coracobrachialis muscle; 9. subscapularis muscle; 10. long head of the triceps brachii muscle. Bar = 1 cm.

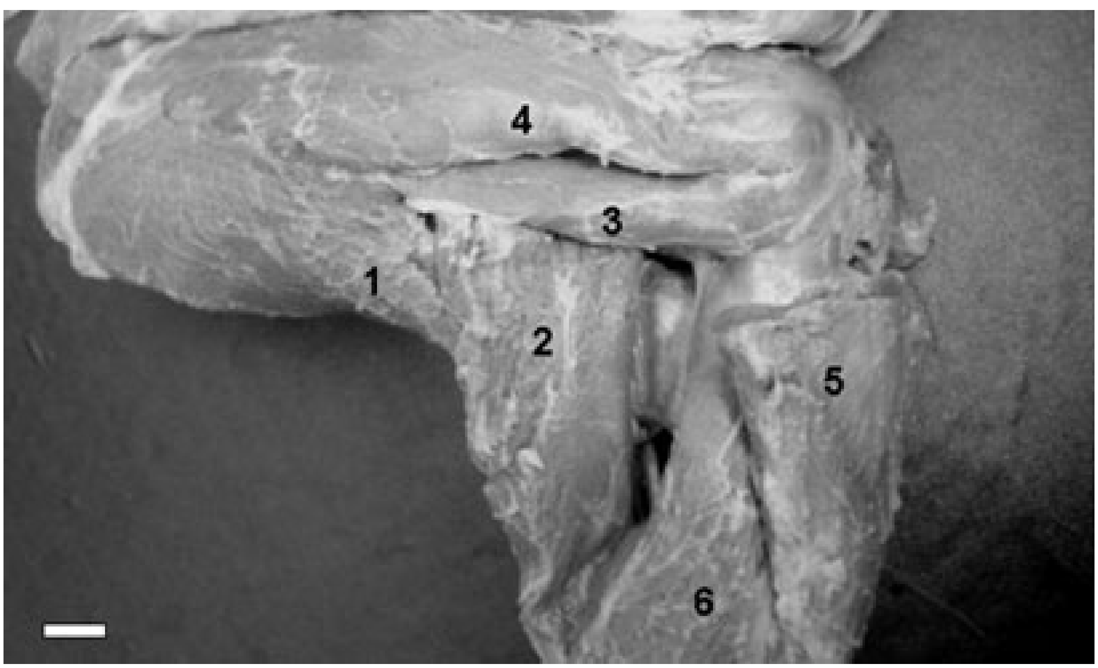

Figure 2. Dorsal view of the shoulder's muscle of the *Cebus*. 1. teres major muscle; 2. long head of the triceps brachii; 3. teres minor muscle; 4. infraespinatus muscle; 5. *deltoid* muscle; 6. lateral head of the triceps brachii muscle. Bar = 1 cm.

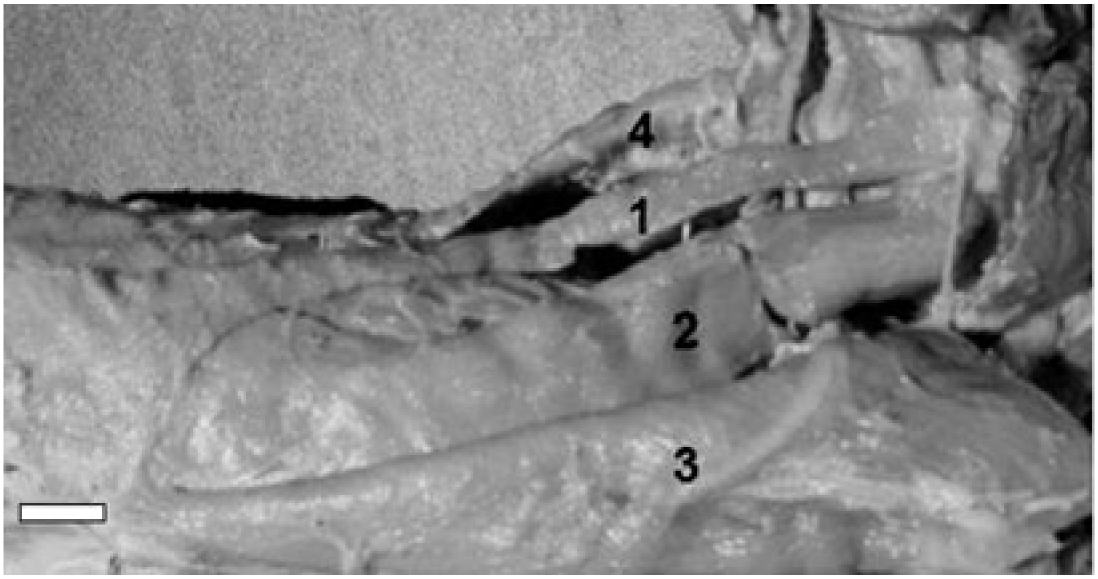

Figure 3. Ventral view of the thorax of the *Cebus*. 1. pectoralis abdominis muscle; 2. pectoralis minor muscle; 3. pectoralis major muscle; 4. latissimus dorsi muscle. Bar = 1 cm

extension of the humerus bone. It shares muscular fibers with the teres major muscle. The insertion of this muscle occurs by a common tendon that covers all of the olecranon extension. The long and lateral heads are united from the distal third part, and the medial head is joined to two others distally.

The *deltoid* muscle (Figs. 3,4) has multiple origins in the clavicle and scapula bones, in the following parts: (1) anterior, being the lateral half part of the clavicle; (2) middle, closely associated with the acromion of the scapula; (3) posterior, fixed throughout all the extension of the spine of the scapula, and inserted at the *deltoid* prominence in the antero-lateral surface of the humerus. This muscle has fibers inserted in the periosteo of the humerus, to the point where it generates an insertion tendon in the *deltoid* prominence; where it shares muscular fibers with the brachialis muscles. It forms the shoulder contour, and is triangular in shape where the thoracic muscle of this primate is in abduction position, forming an angle of 90º with the median axis of the body.

The *latissimus dorsi* muscle (Figs. 3,5) originates in the lumbar aponeurosis, in which it is attached to the lumbar vertebra, and from the spinous processes of the lower thoracic vertebrae, that form a long aponeurosis. It is inserted in the medial lip of the crest of the greater tubercle of the humerus, by a large tendon. The *latissimus dorsi* is very large in the *Cebus* monkey. This muscle forms a superficial muscular veil in the middle-lower portion to the upper-lateral portion, on the dorsal region of the trunk.

The *teres major* muscle (Fig. 4) stems from the lower angle of the scapula, and from the lower third part of the lateral border of this bone. The insertion occurs at the distal third part of the crest of the greater tubercle of the humerus. It has common muscular fibers with the *triceps brachii* muscle (long head). The *teres major* is a cylindrical muscle with both large and short aspects, and forms the lower-lateral border of the axilla.

The *teres minor* muscle (Fig. 4) originates from the upper half area, at the lateral border of the scapula; it exchanges muscular fibers with the *infraspinatus* muscle. This muscle is inserted in the lower half portion of the greater tubercle of the humerus, immediately below the *infraspinatus* muscle's insertion, and originates as a common tendon with the *teres major*.

The *infraespinatus* muscle (Fig. 4) stems from all of the superficial extensions of the infraspinatus fossa; from the spine and medial margin of the scapula, to the lateral margin. The muscular belly is grossly covered by the spinal portion of the *deltoid* muscle, and by the upper border of the *teres major* muscle. The insertion occurs at the greater tubercle, between the insertions of the *supraspinatus* and *teres minor* muscles.

In its origin, the *supraspinatus* muscle takes up the whole of the supraspinatous fossa; and its belly is deep in relation to the *trapezius* muscle. After it continues below the acromion; this muscle is inserted by a large tendon, in the upper surface of the greater tubercle of the humerus bone.

The *subscapularis* muscle (Fig. 3) stems from a short *aponeurosis* that is fixed in the scapula's periosteo, and takes up the entire subscapular fossa. It is inserted by a large tendon, in the superficial area of the lesser tubercle of the humerus.

DISCUSSION

Above we discuss the general characteristics of the muscles of the shoulder and arms of the *Cebus*, in relation to humans, chimpanzees and baboons (Fig. 2). When appropriate, we associate the behavioral aspects with new anatomic data. This comparative data is important as evidence of the differences and similarities between these species. The behavioral aspects of species are also focused.

O´Rahilly [23], Moore and Dalley [20] and Spence's [35] reference to humans and Swindler & Wood's [36] reference to chimpanzees and baboons, are the same, as far as the patterns regarding the description of the *biceps brachii* muscle; the same described for *Cebus*. This in fact, can explain the rough movements produced by this structure, like flexion of the forearm and supination of the hand.

These movements are not associated to skilled aspects of the upper limb, but they are identical, in anatomical aspects, for all primates. The non-human primates do not have sophisticated hand ability as humans do, because the muscles of their hands are mainly used for rough movements, and less for delicate actions; like the contrahent muscles in chimpanzees and baboons [36] and, as in *Cebus*. The strength, or force, of contraction of the hand (grasping and gripping) is privileged in chimpanzees, baboons and *Cebus*; and not nearly so in humans, which do not have the contrahent muscles [36].

O´Rahilly [23], Moore and Dalley [20] and Spence [35] mention a medial insertion of the *coracobrachialis* muscle on the arm, which differs from the *Cebus*, in which this muscle is inserted at the antero-medial position. This insertion assists the strength of the flexion, lateral rotation and adduction movements of the arm, which is important for the brachiation in *Cebus*. Swindler and Wood [36] cite that in baboons, this muscle has two parts: central and deep; again, as in *Cebus*.

O´Rahilly [23], Moore and Dalley [20] and Spence [35] describe the *pectoralis minor* muscle as inserted in the coracoid process of the scapula. Moore and Dalley [20] and Spence [35] describe a proximal origin in the anterior extremities of the third and fifth ribs; similar to what occurs in *Cebus*. Swindler and Wood [36] mention that the origin of this muscle occurs between the third and fifth ribs, near the costochondral joint, as in humans and chimpanzees.

In baboons, the *pectoralis minor* muscle originates in the middle third part of the body, at the sternum, and is inserted in the articular capsule of the shoulder, through a deep pectoral apponeurosis [36]. In chimpanzees, the insertion of this muscle is in the articular capsule of the shoulder, at the coracoid process or in both [36]. In *Cebus*, the insertion occurs at the greater tubercle of the humerus. Therefore, this muscle functions directly on the arm. This also explains why the *Cebus* has an advantage over other primates, in this area, allowing the necessary strength for the constant brachiation movement of *Cebus*.

O´Rahilly [23], Moore and Dalley [20] and Spence [35] refer to humans as having the same origin of the *pectoralis major* muscle described in this study for *Cebus*, except that it originates from the sheath of the *obliquus externus abdominis*, in humans. In *Cebus*, it has been observed closer to the apponeurosis of the *rectus abdominis*. Spence [35] mentions this structure insertion at the greater tubercle of the humerus, and O´Rahilly [23] and Moore & Dalley [20] describe its insertion at the lateral lip of the intertubercular sulcus of the humerus. Interestingly, both insertions occurred in *Cebus*. Swindler and Wood [36] relate that in baboons, the *pectoralis major* muscle originates from the articular capsule of the articulation of the manubrium and the body of the sternum. At every lateral height of the sternum, it is inserted at the lateral lip of the intertubercular sulcus of the humerus, as in humans and *Cebus*. According to Swindler and Wood [36] the aspects defined and cited for *pectoralis major* muscles in chimpanzees are identical to *Cebus*. O´Rahilly [23] describes that the *pectoralis major* muscle acts to adduct, to throw, to push and to excavate; observing that these aspects are not as essential for the actual human survival. In this specie, the pectoralis major muscle still functions as one of the more important muscles, due to the arboreus habits of the *Cebus*. This specie requires large, energetic muscles. This muscle in particular is one of the most used in its daily routine.

Testut and Latarjet [38] mention the existence of an abdominal portion of the *pectoralis major* muscle, originating from the sixth rib, which communicates with the rest of the muscle. In *Cebus* it is termed *pectoralis abdominis*. In describing baboons, Swindler and Wood [36] termed this structure as *pectoralis abdominis*, due to its separation between this muscle and the pectoralis major muscle. The origin of this muscle is identical to the muscle described in baboons. Swindler and Wood [36] mention the absence of the *pectoralis abdominis* in humans and chimpanzees. Other studies have shown that the thoracic limb muscles (forearm) of the *Cebus* are more similar to the muscles of humans and chimpanzees than those of baboons, but the existence of this muscle in *Cebus* is an exception [3,4,5].

O´Rahilly [23], Moore and Dalley [20] and Spence [35] related that the *brachialis* appears in the anterior surface, from the distal half of the humerus, and is inserted at the coronoid process of the ulna in humans. Swindler and Wood [36] mention the same origin and insertion of this structure in humans, baboons and chimpanzees. Our descriptions of these muscles to *Cebus* are equal to humans, baboons and chimpanzees. Similarly, in the discussion of the biceps brachii muscle: the *brachialis* muscle range is small between species. This may be due to the same reason explained in the above interpretation: it is the use of these structures for movements, providing strength in all primates. Specifically, the axis of the muscle's movement is bidimensional.

O´Rahilly [23], Moore and Dalley [20] and Spence [35] describe the *anconeus* muscle in terms of origin and insertion. Our description for *Cebus* equals their findings. Swindler and Wood [36] do not relate the origin and insertion of the *anconeus* muscle. However, they mention that it is an insignificant muscular portion derived from the primitive complex triceps, and can be absent in humans. Testut and Latarjet [38] describe the *anconeus* muscle as an area of the triceps, which was corroborated by Swindler and Wood [36]. Moore and Dalley [20] refer to a stabilizing function of the elbow joint, a tensor of the articular capsule mentioned, preventing its compression during the extension of this articulation. O´Rahilly [23] attributes its function as a stabilizer of the forearm articulation, and Spence [35] and Testut and Latarjet [38] mention its only function as an extensor of the forearm. In *Cebus*, the analysis of the position, origin and insertion only indicates its function as an auxiliary of the triceps muscle, during the extension of the forearm.

O´Rahilly [23], Moore and Dalley [20] and Spence [35] describe the origin of the *triceps brachii* muscle as appearing through infraglenoid tuberosity of the scapula, and its insertion in the olecranon of the ulna. It is the principal extensor of the forearm, and its long head stabilizes the head of the humerus when it is in adduction [20]. According to Spence [35], the long head extends the arm. Swindler and Wood [36] mention a wide origin of the long head of the *triceps brachii* muscle, similar to what we described for *Cebus*. It forms the triangular space related in human anatomy. In humans, the other heads of the triceps have identical origin of the same portions, and this data agrees with our results in *Cebus*. The insertion is the same in all studied species. The important aspects are that the long head has more elaborate functions than those of other heads of the triceps, like the stabilization of the humerus and the extension of the arm. Such aspects can also be deduced for *Cebus*, but the wider origin of the long head of the triceps, in non-human primates, is indicative of this muscle's strength required for the habits of these animals.

In humans, the *deltoideus* muscle was described as having three parts by O´Rahilly [23], Moore and Dalley [20] and Spence [35], and the same description was given by Swindler and Wood [36] in baboons and chimpanzees. These portions are defined by the functions of the origin of the *deltoid*eus muscle from the clavicle (anterior part), the acromion (middle part), and the spine of the scapula (posterior part).

These portions are also described for *Cebus*, preserving high similarity with the other primates. The origin is also the same in *Cebus*, as in humans [20,23,35] and in baboons and chimpanzees [36]. In *Cebus*, similar to baboons and chimpanzees, the insertion of the *deltoid*eus muscle is most distal at the *deltoid* tuberosity. However, Swindler and Wood [36] relate that the quadrupedal habit of the baboons produces a more distal insertion at the humerus than that of the brachiation habit in chimpanzees, of which such insertion is more similar to humans.

In *Cebus*, the insertion of the *deltoideous* muscle is much more distal than it is in humans, and this fact is justified due to the locomotion by *Cebus*, in both quadrupedal or brachiation habits. In this case, according to speculations made by Swindler and Wood [36], insertion of the *deltoid*eous show the quadrupedal habit as the favorite in *Cebus*. We have observed many groups of the *Cebus*, near the Federal University of Goiás and they prefer to run with all four limbs. When they stop in one place, in search of food, they support themselves with their pelvic members; freeing their hands to get food or objects on the ground. They also run in the bipedal position, as corroborated by observations of Lopes [17]. In *Cebus*, it has been observed that a bipedal movement is used during determinate movements on the ground, while the primate is used to support its tail when it is in the erect posture. This posture is justified with the purpose to free its hands to carry its young, as well as objects. Also known as the "feeding posture," the bipedism allows the approach to feed, for what it could not previously reach. Besides, this posture competently enables the manipulation and arrangement of tools, characteristics rarely observed in other neothropical primates [10,13].

Behavioral data show this deduction, therefore: that on the ground, these animal movements are made using all four limbs, although they prefer being on the two pelvic members supported by the tail, when grasping objects or food.

In humans, Moore and Dalley [20] report that the *latissimus dorsi* muscle arises from the spinous processes of the lower six thoracic vertebrae, the thoracolumbar aponeurosis, the posterior crest of the ilium, and the three or four lower ribs. As origin, O´Rahilly [23] considers the inferior angle of the scapula, and Spence [35] refers to the sacrum bone as the origin of the latissimus dorsi. All of these authors agree as to the insertion of the *latissimus dorsi* muscle on the intertubercular groove of the humerus.

In baboons, Swindler and Wood [36] describe the origin of the *latissimus dorsi* muscle as having been in the lower six thoracic vertebrae, the lumbar vertebrae and the lumbar aponeurosis. In chimpanzees, they mention an origin similar to that in humans. With regard to the insertion, it is identical in the three species. The origin of the *latissimus dorsi* muscle in *Cebus* is most similar to that of the baboons, and it has the same insertion point related in other species. It is a potent extensor and adductor of the arm and has an important function in the quadrupedal movement, which is common in baboons as well as in *Cebus*, when they run along the ground. May be this fact explains the similarity of this structure in baboons and *Cebus*, in regard to its origin, as well as the similarities shared with the *deltoideus* muscle. The *latissimus dorsi* muscle elevates the body towards the arm during climbing [20] in humans, and such a movement is very important for *Cebus* to climb trees, as is the brachiation movement.

The *teres major* muscle originates on the dorsal surface of the lower angle of the scapula [20,23,35], and it is inserted on the medial lip of the intertubercular groove of the humerus, according to Moore and Dalley [20] and O´Rahilly [23]. Spence [35] details its insertion at the lesser tubercle of the humerus.

Swindler and Wood [36] relate the origin and insertion of the *teres major* muscle as identical to humans, but agree with the descriptions by Moore and Dalley [20] and O´Rahilly [23]. Our findings also show the same origin of this structure in *Cebus* to those related in humans, chimpanzees and baboons; but its insertion is different. In *Cebus*, the *teres major* muscle is inserted in the greater tubercle of the humerus, and its principal functions are as adductor and medial rotator of the arm.

The *teres minor* muscle arises from the lateral border of the scapula, and it is inserted in the greater tubercle of the humerus in humans [20,23,35]. Swindler and Wood [36] mention the same origin and insertion of this muscle in chimpanzees and baboons, and that it relates to humans. The authors further describe the union between the *teres minor* and the *infraspinatus* muscles, mainly in its proximal portion. In *Cebus*, our results show similarity of the origin and insertion of this muscle, with references to the description of other species studied here. The position, origin and insertion of this muscle indicate its function. In *Cebus*, it stabilizes the shoulder joint, as well as in humans [20,23,25], and its union with the *infraspinatus muscle* occurs both in the proximal and distal portions of these muscles.

The *infraspinatus muscle* originates in the infraspinatous fossa of the scapula, and is inserted in the greater tubercle of the humerus [20,23,25]. In baboons and chimpanzees, the origin and insertion are similar to the occurrence in humans [36]. The description of this muscle in *Cebus* is identical to that in the other primates studied here, and its position and insertion indicate its stabilizing function of the shoulder articulation.

O´Rahilly [23], Moore and Dalley [20] and Spence [35] refer to the *supraspinatus* muscle as originating in the supraspinatous fossa, and inserted in the greater tubercle of the humerus. Swindler and Wood [36] relate both origin and insertion in baboons and chimpanzees to similarities found in humans. In *Cebus*, the origin and insertion are also similar, and in association with the teres minor and infraspinatus muscles, these aspects assist in the stabilization of the shoulder joint.

O´Rahilly [23], Moore and Dalley {20} and Spence [35] related studies on humans, and Swindler and Wood [36], on chimpanzees and baboons. Our results regarding *Cebus* are in accord with the origin and insertion of the *subscapularis muscle*. They are the subscapular fossa and lesser tubercle of the humerus, respectively. In *Cebus*, considering the aspects such as position and insertion, this muscle also acts as a stabilizer of the shoulder joint.

The *teres minor*, *infraspinatus*, *supraspinatus* and *suscapularis* muscles form the rotator cuff in *Cebus*, identical to humans, chimpanzees and baboons.

The triceps, the lateral and medial heads, the *brachialis* muscle, the *biceps brachii* and the *anconeus* muscles, all have identical morphological aspects, in all the primates studied here (Table 2). However, the *deltoideus muscle*, the long head of the triceps muscle, and the *latissimus dorsi* muscle show divergent morphologies between species. In these cases, the structures in *Cebus* are more similar to those in baboons (Fig. 2), perhaps due to the quadrupedal habit. When baboons run on the ground, it is necessary to use the pulling force by the thoracic member to succeed in this action. In other studies, the muscles of the forearm of the *Cebus* show more similarity with muscles of the chimpanzees than those of the baboons.

This data can indicate a common adaptation, leading to the selection of the intermediate characteristics between baboons and chimpanzees. Thus, *Cebus* run on the ground as baboons, and have motor abilities to tool use like chimpanzees. This data on evolutionary aspects are corroborated by other studies [3,4,5] that show high similarities between the forearm muscles of *Cebus*, chimpanzees and humans, but to these same structures these muscles are different to baboons. (see tables 1 and 2)

CONCLUSION

The shoulder and arm muscles of *Cebus*, in general terms, are similar to the same muscles in humans, chimpanzees and baboons. These indicate the same evolutionary origin, but the muscles responsible for soil locomotion, exhibit more similarities with the baboon muscles. This is mainly due to the quadrupedal habits of these animals, which indicate the evolutionary convergence aspects between baboons and *Cebus*.

Muscles	Origin	Insertion
Biceps brachial	Short head: coracoid process of scapula; Lateral head: supraglenoid tuberosity	Tuberosity of the radio and; superficial fascia of lateral portion of the forearm
Coracobrachialis	Coracoid process of scapula	Middle third portion of the humerus
Pectoralis minor	Lateral border of the sternum and; second to fifth ribs	Greater tubercle of the humerus
Pectoralis major	Lateral border of the sternum bone; Medial two third part of the clavicle and; anterior lamina of the aponeurosis of the rectus abdominis muscle	Crests of the greater tubercle and; intertubercular lips in the proximal third part of the humerus
Pectoralis abdominis	Lateral border of the sheath of rectus abdominis muscle.	Greater tubercle of the humerus
Brachialis	*Deltoid* tuberosity of the humerus and; distal two third part of antero-lateral surface of humerus	Tuberosity of ulna
Anconeous	Posterior part of the lateral epicondyle of the humerus	Lateral portion of olecranon
Triceps brachii	Long head: tuberosity of scapula and aponeurosis of the supraespinatus, teres major muscles Lateral head: proximal third part of the humerus Medial head: postero-medial surface of the humerus	Olecranon
Deltoid	Anterior: lateral half part of the clavicle; Middle: acromion of scapula; Posterior: spine of scapula	*Deltoid* proeminence in the antero-lateral surface of the humerus
Latissimus dorsi	Lumbar aponeurosis	Medial lip of the crest of the greater tubercle of the humerus
Teres major	Inferior angle of the scapula and; Inferior third part of the lateral border of the scapula	Distal part of the crest of the greater tubercle of the humerus
Teres minor	Superior half part at lateral border of the scapula	Inferior half part of the greater tubercle of the humerus
Infraespinatus	Infraespinatus fossa and spine of the scapula and lateral and medial margin ones	Greate tubercle of the humerus
Supraspinatus	Supraspinatous fossa	Superior surface of the greater tubercle of the humerus
Subscapularis	Subscapular fossa	Lesser tubercle of the humerus

Table 1

Muscles	Similarities
Biceps brachial	Humans, chimpanzees and baboons
Coracobrachialis	Baboons
Pectoralis minor	Different of the others
Pectoralis major	More similarities to baboons
Pectoralis abdominis	Baboons
Brachialis	Humans, chimpanzees and baboons
Anconeous	Humans (no related on others primates cited here)
Triceps brachii	Humans, chimpanzees and baboons to medial and lateral head; identical to baboons to long head.
Deltoid	Baboons
Latissimus dorsi	Baboons
Teres major	Equal origin to humans, chimpanzees and baboons; but insertion is different of the others
Teres minor	Humans, chimpanzees and baboons
Infraespinatus	Humans, chimpanzees and baboons
Supraspinatus	Humans, chimpanzees and baboons
Subscapularis	Humans, chimpanzees and baboons

Table 2. Similarities between muscles of the shoulder and arm of the *Cebus*, chimpanzee, baboon and human

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