

Comparison of the Upper and Lower Limbs-A Phylogenetic Concept

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Abstract: The upper and lower limbs of the human body are phylogenetically homologues of the forelimbs and hind limbs of the quadrupeds. Primates started lifting of the forelimbs off the ground for various functional adaptations as evolution progressed and this led to the deviation of the forelimbs from lower limbs. With the gradual diversification of the functions, morphological evolution of the two limbs follows closely leading to the differences in upper and the lower limbs in the human. Since the inception of the Anatomy as one of the curriculum in medical subjects, the anatomical position has been termed as one that the body stand erect with the eyes looking straight forward and the two upper limbs hanging by the side of the body with the palm facing forward. Therefore in this position the upper limb looked forward with the palm also accordingly faced forward too whilst with the thumb on the lateral side whilst in the lower limb, the big toe which is homologous to the thumb, is placed on the medial side. The anatomical position in the upper limb is not normally a comfortable position as it is kept in this position with effort. Under normal circumstances, the upper limb assumes a pronated position. It is questionable whether we should continue to call it anatomical position, a term that had been used by the authors in the past, in spite of the fact that it yielded and is responsible for the differences in the upper and lower limbs of the human.

Keywords: Anatomical position, phylogeny, homologous, pronation.

I. Introduction

Anatomical position is described in Anatomy textbooks as the position of the body in standing position with the palm facing forward, thumb on the lateral side, the little finger on medial side and the toes pointing forward with the big toe on the medial side. In the humans, the gross difference in the upper and lower limbs is that the flexor and extensor surfaces and their functional groups of muscles are in the opposite directions i.e. flexor surfaces or muscles in the upper limbs are placed anteriorly whilst in the lower limbs, it is the extensor surfaces or group of muscles which are placed anteriorly. Carrying angle, which is the angle between the long axes of forearm and the arm and it is apparent and present only in the supinated forearm whereas in pronation it is compromised and absent thus the forearm and arm are almost in alignment and the upper limb is kept in natural position without any effort. The forelimbs of the quadrupeds are homologous with the upper limbs of the human. In them as the forelimbs too have to bear weight unlike in humans, they are kept pronated with the thumb on the medial side and the palm in contact with the ground like the hindlimb.

Both the limbs in the human have three segments in upper limb i.e. arm (upper), forearm (middle) and hand (distal) as that in the lower limb i.e. thigh (upper), leg (middle), and foot (distal). The upper and lower limbs are fixed to the trunk by the pectoral and pelvic girdles respectively. As evolution progressed, the forelimbs of the quadrupeds gradually lifted off the ground so as to free themselves for use in reaching, grasping and prehensile functions whilst the hind limbs remained on the ground under the body weight. With these functional adaptations the morphological deviations of these limbs from the hind limbs began to establish. The resultant differences between the upper and lower limbs in the human are laid down here in (table 1).

Table 1. Morphological differences between the upper and lower limbs

	Upper limb			Lower limb		
1. Size	Smaller and shorter			Larger and longer		
2. Mobility	Less firmly attached to trunk and more mobile			More firmly attached to trunk and less mobile		
3. Function	Grasping and skilled movement			Weight bearing and locomotion		
4. Segment	Arm	Forearm	Hand	Thigh	Leg	Foot
5. Bony framework	Single bone (humerus)	2 bones (Radius and Ulna)	Carpals, metacarpals and phalanges	Single bone (femur)	2 bones (Tibia and Fibula)	Tarsals, Metatarsals and Phalanges
6. No. of Compartments	2 compartments	3 compartments		2 compartments	3 compartments	
7. Alignment of distal parts			Aligned along the axis of the limb			Placed at right angle with the axis of the limb
8. Position of pollex/hallux in anatomical position			Laterally placed			Medially placed
9. Position of flexor surface/muscle	Anteriorly			Posteriorly		
10. Position of flexor surface/muscle	Posteriorly			Anteriorly		
11. Carrying angle	Present			Absent		

II. Materials and Methods

Indepth morphological and anatomical analysis between the apes and the quadruped and comparison of the forelimbs and hindlimbs of the quadrupeds with the upper and lower limbs of the human and apes were done phylogenetically. The study also included apes as the middle level primates in the journey of evolution.

III. Results

The forelimbs and hindlimbs of quadrupeds were similar both morphologically and functionally. Both limbs were in pronated position with their big toe on the medial side with no difference in the dispositions of functional groups of muscles. In primates, the forelimb homologues started lifting off and on for reaching, hanging, eating and prehensile functions. The forelimbs were no longer under the gravity of the weight of the body as in quadrupeds and were free to supinate and undergo axial rotation thereby changing the position of the postaxial borders. However, the hind limbs still remained in contact with ground i.e. under the gravity of the body weight as in the quadrupeds and so adopt pronated and there was least chance of any axial rotation of these limbs.

IV. Discussion

The upper limbs (forelimbs of quadrupeds) have become gradually free as the process of evolution reaches primates, gradually exhibiting the difference between these limbs and lower limbs (hind limbs in quadrupeds) in humans. Reversal of the surfaces in these two limbs is found in the presently described anatomical position. The upper arm has only two compartments viz. anterior (or flexor) and posterior (or extensor). In the thigh, there are three compartments viz. anterior (extensor), posterior (flexor) and medial (adductor). These differences between the two limbs have been attributed to reverse axial rotation during development (Moore and Persaud 2008)². Ultimately the extensor muscles have come to lie anteriorly in lower limb (Palastanga et al 2002)³. In the lower limb, an additional or third compartment has been added as a separate compartment for the abductors (abductor longus, abductor brevis abductor magnus, gracilis and part of the pectineus with the obturator nerve from the ventral divisions of the lumbar plexus as its nerve). Its counterpart in the upper limb is represented by the phylogenetically degenerated muscle, coracobrachialis which is supplied by the musculocutaneous nerve (McMinn 1994; Palastanga et al 2002)¹. However, the present author is of the opinion that the deviation of the morphology of the upper limb from that of the lower limb begins as the forelimb is lifted off the ground and freed of the thrust of the gravity of the body of weight. In quadrupeds, the gravity of the body weight acts on the ground firmly and so they are not free to move i.e. supinate or axially rotate. In nonhuman primates, e.g. monkeys and apes, the forelimbs have the characteristics of both quadrupeds in that they are used to bear weight and by making contact with the ground they are used for locomotion off and on but at the same time like in the human they are lifted off the ground and used for grasping, reaching, eating and can supinate and undergo axial rotation at will. Thus, the thrust of the body weight in the forelimbs firmly keeps these limbs in contact with the ground not allowing any deviation from its hind limb counterparts in the quadrupeds. In the human newborn, the positions of the forelimbs and hind limbs are almost similar. In the lower limb, the big toe is almost on the lateral side and the sole faces upward. At this stage no body weight thrust acts through the lower limbs. However, when the child grows and is able to stand the thrust of the body weight is passed on the

lower limbs gradually bringing them to pronated position with the big toe on the medial side as in adult humans or quadrupeds. Thus, the pronated position of the human adult is solely due to the thrust of body weight.

The anatomical position, as has been described in the textbooks of Anatomy, is responsible for some of the gross differences of the upper and lower limbs in human beings. Thus, in the upper limb, flexor surfaces face forward contrary to those of the lower limb which face posteriorly and the thumb is on lateral side contrary to big toe which lies on medial side. The present author is of the opinion that the existing or conventional concept of anatomical position has brought about disparity between the upper and lower limbs regarding the direction of the functional groups of muscles representing the flexor and extensor surfaces. The anatomical position of upper limbs is maintained with the lateral rotation these limbs through the vertical axis.

This is done with effort and so it is not a comfortable position. Usually, under relaxed conditions, the two upper limbs hang by the side of the body in the pronated position with the thumb on medial side and little finger on the lateral side, thereby nullifying the carrying angle. Had this position been named "anatomical position" the disparity between the upper and lower limb would not have existed at all. The extensor and flexor groups of muscles and surfaces are no longer strictly based on anterior and posterior surfaces and exhibit interchangeability according to the functional needs or conditions. However, in spite of these new functional adaptations, the upper limbs are still used occasionally for locomotion and weight bearing also.

In humans, the forelimbs i.e. upper limbs have become totally free of the ground. The hind limbs i.e. lower limbs which are placed totally in the same axial line with the body, the total body weight being subjected to them, assume pronated position with the big toe on medial side and the exterior surface facing forward and flexor surface (flexor group of muscles) backward as in the quadrupeds. An extra compartment of muscles has been added as adductor/medial compartment in the thigh and peroneal/lateral compartment in the leg. In the anatomical position, the upper limb is placed in such a way that the palm faces forward, its surface entirely opposite to that of the forelimbs of the quadrupeds.

References

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