ANATOMIC CHANGES OF THE HUMAN SKELETON AS A RESULT OF BIPEDALISM

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Abstract: *As time passed by, natural selection gave humans a set of heterogeneous features, which based on certain behavioural modifications stimulated the transformation of the human anatomy. Bipedalism is one of the most important characteristics of humans, being the first important change that occurred in our evolution, which determined modifications in structure and function of some of the organs, resulting in the actual configuration. The most accepted theory about human evolution acknowledges that standing on two limbs generated a chain reaction of anatomy changes. The adjustments of the axial skeleton due to the new posture generated changes in the inferior limbs as well, which needed to support the bodyweight. The result was a transformation of the aspect, form and function, serving posture and locomotion as well. The superior limbs were now free, and able to execute precise actions coordinated by the large brain. Evolution couldn't act precisely as an engineer, on the contrary it accepted compromises, all the new benefits were to be paid in time with imperfections and functional weaknesses.*

Keywords: *bipedalism, human anatomy, human skeleton*

Rezumat: *Selecţia naturală a oferit omului, de-a lungul timpului, un mozaic de trăsături care pe seama unor modificări comportamentale a stimulat modificarea anatomiei. Bipedia este una dintre cele mai importante caracteristici ale omului actual, fiind prima modificare evolutivă importantă, care a antrenat o modificare in constituţia, structura şi funcţia unor organe, având ca rezultat apariţia omului actual. Cea mai larg acceptată teorie asupra evoluţiei omului recunoaşte bipedia ca fiind ceea ce a declanşat lanţul adaptărilor anatomice. Modificările scheletului axial ca rezultat al noii posturi adoptate au acţionat şi asupra membrelor inferioare, care au preluat greutatea, transformând forma şi în final funcţionalitatea, adaptându-se la statică şi locomoţie. Membrele anterioare au putut fi libere pentru a putea executa miscări fine şi precise coordonate de creierul care crescuse în dimensiuni. Evoluţia nu a acţionat însă asemenea unui inginer, ci a acceptat compromisuri, capacităţile câştigate în timp fiind însoţite de imperfecţiuni şi slăbiciuni funcţionale.*

Cuvinte cheie: *bipedia, anatomia umană, schelet uman*

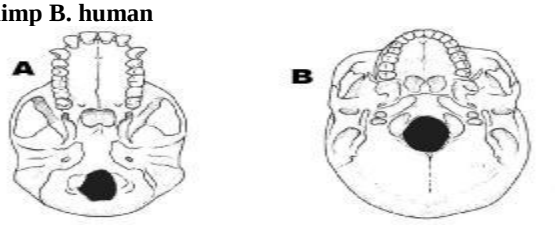
INTRODUCTION

The study of the human skeletal system represents a good way to emphasize the modifications that humans suffered as a result of the adaptation to the bipedal posture. From the phylogenetical point of view, it is unanimously accepted that the skeletal system is the first structure of the body that admitted well structured changes that had an effect on other systems and structures of the human body. From the cranium, vertebral column, to the limbs, the skeletal system embodies the anatomical marks of the necessarily transformations of the new posture and the new way of life, which as a whole, defines the aspect and functionality of the actual human. Whether we refer to the centralization of the foramen magnum, physiological curvatures of the vertebral column, enlargement of the pelvis, or the formation of the plantar arches, the diversity of the anatomical structures raises question marks above the necessity and efficiency of these evolutionary modifications.

AXIAL SKELETON

The skull suffered modifications in regarding size, the neurocranium increased its volume due to the need of a larger brain. This aspect has a disadvantage represented by the difficult parturition, but the positive aspect is marked by the possibility of the brain to develop in a greater amount after birth, the human brain at birth represents 25% of the adult brain volume. The facial part is less prominent, instead the temporo-mandibular joint achieved in humans the most evolved phylogenetic form allowing movements in all 3 dimensions.

Picture no. 1. Inferior view of the basi cranium A. chimp B. human



By far the most important modification of the skull is represented by the centralization of foramen magnum, which meant the stabilization of the cranium in

the context of the new posture adopted as a need of great mobility. Together with the cervical part of the vertebral column, the first 2 cervical vertebrae more precisely (considered transitional vertebrae) humans can perform flexion (10º), extension (25º) movements – in the atlanto-occipital joint, and axial rotation (45º) and lateral flexion (30º) in the atlanto epistropheus joint.

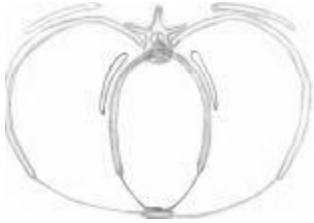
Picture no. 2. Orientation of the first and second cervical vertebrae A. maccacus B. human after F. Ankel-Simons

The vertebral column represents a very important structure as a whole. Its constitutive elements, rigid (vertebrae) and deformable (the intervertebral discs), insignificant piece by piece, form a unique structure among vertebrates. The result is a compromise between contradictory functions: the equilibrium needed to sustain the weight of the body, remarkable mobility and protection of the spinal cord. This set of features determined in curvatures in the sagittal plane, except the thoracic and sacral kyphosis which are considered primary, being present at birth, the cervical and lumbar lordosis are secondary curvatures, compensatory , which shape up along with the gait and maintaining the head in a vertical position.

Picture no. 3. The vertebral column A. quadruped (gorilla) B. human

The vertebral column's position in the bony thorax has changed from being eccentrically situated in the quadrupeds, to a more centered position, also affecting the obliquity of the ribs, and the general aspect of the bony thorax.

Picture no. 4. Transversal section through the rib cage in human (red) and maccacus (quadruped) F. Ankel-Simons



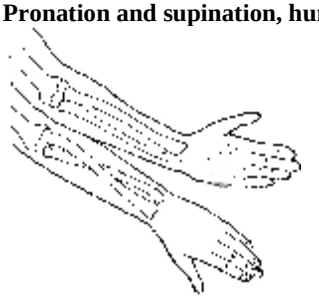
APPENDICULAR SKELETON

Ever since man rose off the ground, the upper limb was "freed" from the burden of holding the body weight. As a result the upper limb started to be used in various activities that simultaneously with the development of the brain conferred a more and more humanly aspect of the upper limb.

Mobility is the dominant feature resulted in the anatomical modifications. The muscles of the forearm develop forces that change the aspect of the humerus by torsioning the distal end.

The aspect of the bones of the upper limb favours mobility, the forearm allowing a rotation movement created by the rotation of the distal extremity of the radius around the head of the ulna, and thus so the pronation -supination movements are generated.

Picture no.5. Pronation and supination, human



Due to the capability of prehension the hand is the most distinguished segment of the upper limb. This is possible only because of the opposition of the polex, the adduction, flexion and axial rotation movements are combined to define an extremely precise biomechanical act and efficient too. As a result the hand could now be used in tool making, relating to other humans and to more and more refined activities.

Picture no.6 Opposition of the pollex

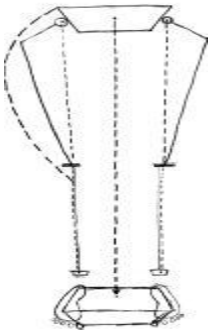
Unlike the upper limb, the lower limb still supports the body weight, being the principal factor for maintaining the vertical position, its morphology is deeply reflecting this adaptation.

The pelvis suffered notable modifications, the sacrum changed its position, leaning forward, transmitting the body weight from the vertebral column to the inferior limbs and modifying the centre body weight.

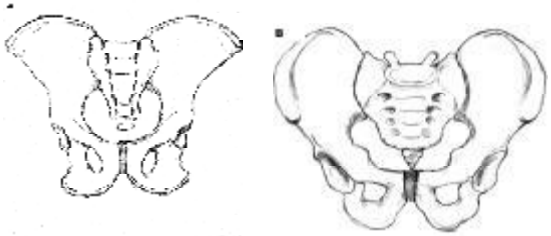
The ilium had flattened and changed its orientation- from the coronary plane at quadrupeds – rotated and torsionated medially due to muscle traction. The muscles of the thigh are very well represented in

humans this reflects in the rugged aspect of the hip bone. Some of the muscles of the lower limb have different functions, like the gluteus medius and minor that no longer executes extensory movements, they have an abductor function. The gluteal region developed very well because of the gluteus major, powerful extensor of the hip, and with a very important role in stabilizing the limb.

Picture no. 7. Center body mass – after D. M. Antonescu

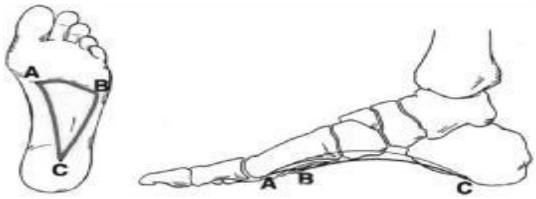


Picture no. 8. Comparative aspect of the pelvis A. quadruped(chimp) B. human after R. Lewin



The angle of inclination (130º) and declination (12-15º) offered great mobility to the femur, the physiological values created by these angles appears along with the standing position and with the first steps of a baby, the result being the stabilization of the inferior limb. Lastly the body weight determined considerable changes in the aspect and functionality of the foot. The tarsal and metatarsal bones are placed in a system of arches that are sustained by passive (plantar aponeurosis) and active factors (muscles of the calf and foot) which contributes to the efficient bipedal standing.

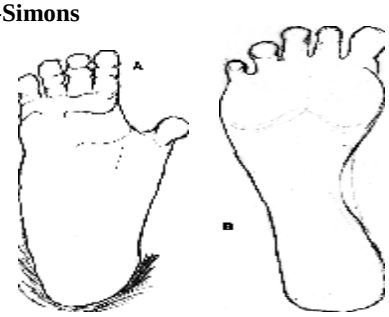
Picture no.9. Plantar arches



Unlike the upper limb, the first finger loses the opposability capacity and aligns in the axis of the foot alongside with the other fingers, losing the abilities that primates can accomplish with the foot, in favour of the vertical standing.

The lower limb's functionality is divided between assuring in the same time standing and mobility, the pelvis being responsible for the static function, and the foot responds the need of a long time dynamic activity.

Picture no.10. Losing the opposability capacity Plantar view of the foot A. gorilla B. human - after F.Ankel-Simons



CONCLUSIONS

The human skeletal system in the context of bipedalism is characterized by the mutual relation between morphology and function, the necessity of fulfilling a certain function determines a change in morphology, just as any morphological change will have a response from the functional point of view.

When the human adopted the bipedal standing he achieved something more than just rising off the ground. Helped by the morphological compromises and the favourable evolutionary events, the human reached the top of the phylogenetical scale. Although he is the last on the list of the important evolutions of the living world, the human represents the most evolved of the species capable of understanding important aspects regarding his life from his past, present or onto the future; that's why the simple back pain that we all feel could be a modification of the skeletal system due to the sedentary life, vicious positions requested by modern life, which could threaten to disrupt the equilibrium achieved along millions of years.

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