MAN'S ERECT POSTURE

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This lecture is an attempt to describe briefly how, when and where Man came by his erect attitude.

Though the upright posture is one of the great and most conspicuous of human characteristics, several animals, as the squirrel, bear, kangaroo and some of the monkeys and apes, can maintain their trunk upright; even some of the extinct dinosaurs are known to have walked upright. In this connection it is interesting that surveys have constantly shown that the animals most favourite with children are those whose postures are in some ways or at some times rather vertical, as the chimpanzee, the monkey, as well as the penguin, the most vertical of all birds.

In primitive aquatic animals, the limbs are propelling non-supporting organs being mobile but with little stability. With the change from the aquatic to the terrestrial habitat, the limbs have to temporarily lift and support the body weight during the act of propulsion while at the same time maintaining their propelling function, so that some more stability is added to their mobility. In the terrestrial four-footed pronograde animals, all 4 limbs become permanently supporting though ambulatory organs. Some of these animals, however, move forwards by a hopping type of movement during which the hind limbs take an increasing share of supporting the body weight; this becomes even more so with the adoption of arboreal life where the animal advances along the branches of a tree by reaching ahead for new holds with its front limbs. Finally the fore-limbs lose their function of support and, while the animal is in motion, the hind limbs become the only support of the body. These characteristic stages in the development of the upright or orthograde posture culminate in the evolution of plantigrade Man when fore-limbs and hind-limbs acquire human characteristics and the typical poise of the head is attained.

Man's posture has evolved through 3 stages. In the Hylobatian stage the pronograde monkey differentiated into the gibbon, a small anthropoid which is orthograde in its gait, holding the body upright in the phase of progression, but which rests and even sleeps in the sitting position. In the Troglodyte stage the small anthropoids differentiated into the great anthropoids (e.g. chimpanzee, gorilla and orangutan), animals which, being heavier, have a more marked orthograde posture and gait, and which rest only when the body is laid prone. In the final Plantigrade stage, characterised by Man, structural changes took place which were almost entirely confined to the lower limbs.

The evolution of the erect posture entailed structural as well as physiological alterations in all parts and systems of the body. Most of these changes occurred in the adaptation to arboreal life but some were more recent, resulting from the achievement of Man to walk upright.

The basic change in the evolution of posture was the shift in the body's centre of gravity. As we move up the evolutionary scale, the centre of gravity tends to move backwards from the head and shoulder to the hind-limb and tail region. In leaping animals, the hind-limbs increase in size and the tail enlarges, the centre of gravity coming closer to the organ of propulsion (the hind-limbs). Higher up in evolution, the centre of gravity tends to move well back over the hind-limbs, so allowing the sitting position and freeing

the fore-limbs for manipulation and, later on, enabling Man to stand.

Four-footed animals use their mouth as a food-getting organ so that this is situated as far as possible from the face, especially from the eyes; these animals, therefore have a long snout. With the development of the erect posture and the consequent use of the fore-limbs for grasping, the animal now seizes the food with its hand and so conveys it to the mouth, with a consequent gradual recession of the snout region. The snout is, however, still quite large in the Great Anthropoids and its final recession is only reached in Man.

With the recession of the snout, the cranial becomes larger than the facial part of the skull, the reverse of the situation in the lower primates. The occipital condyles, which articulate with the vertebral column, move forwards on the base of the skull so leading to an increasing diminution in the angle between the axes of the head and that of the trunk and this ultimately becomes almost a right angle. There is a consequent reduction in the strength and attachment of the muscles at the back of the neck and the development in Man of counterbalancing muscles on the front, such as the sternomastoid. Ultimately, the characteristic head-poise of Man is attained, the whole skull becoming practically balanced on the vertebral column; this poise not only permits an increased range of movement, but also allows the head to be placed to best advantage to catch sounds coming from any direction(so that the movements of the pinna of the ear remain no longer necessary).

Simultaneously, changes occur in the vertebral column. With the evolution of the orthograde from the pronograde posture there is shortening of the lumbar spine by sacralisation in a headward direction, but with the change later on into the plantigrade posture of Man, there is relengthening of the lumbar spine by sacralisation in a tailward direction as well as by an increase at the upper end of the lumbar vertebral series. Apart from alterations which occur in the curvatures of the vertebral column as the result of changes in the centre of gravity, there are also changes in its type of movement. In four-footed monkeys which leap from the hind-limbs, the lumbar spine acts as a flexible lever which moves the upper part of the body on a fixed pelvic base, the centre of gravity being the anticlinal vertebra, i.e. that vertebra with a straight spine which separates the retroverted thoracic from the anteverted lumbar spines. In the bipedal anthropoid and in Man, this springing in the middle of the backbone is absent and the vertebral column, whose spines are uniformly sloping, acts as a whole — as a pillar rather than a spring. Associated with this change in the type of movement, structural modifications occur in the spinal muscles, especially those of the lumbar region; these gain an ever-increasing attachment to the pelvis so rendering this a fixed base from which the erector spinae may act.

In four-footed animals the pelvic outlet looks backwards and forms the highest part of the abdominal cavity, the symphysis is at the lowest part of the pelvis, and a tail is still present. With the assumption of the upright posture, the pelvic outlet becomes the lowest part of the abdominal cavity, the symphysis moves up in the direction of the umbilicus, there is a widening of the subpubis arch, and early coccygealisation and disappearance of the tail. The increase in the pelvic outlet anteriorly, the added weight of the abdominal contents, the increase in the intra-abdominal pressure bearing on the pelvic floor, which now lies horizontally, and the disappearance of the tail (which normally acts as a perineal shutter) all lead to a weakening of the pelvic outlet in the bipedal posture. This could possibly account for conditions like uterine and rectal prolapse occurring in orthograde but not in pronograde animals.

Anthropoids appear typically "slouched forward". Structurally there is no difference between the anthropoid and the human shoulder and Man only keeps his shoulders braced back because the supporting reflex postural mechanism has in him been perfected. The bones of the

arm are longer in the brachiators and thicker in the heavier anthropoids. The hands in orthograde animals and in Man assume functions which they do not have in the pronogrades. Four-footed animals rely mostly on their teeth for their offence and defence reactions but Man uses his hands for these purposes; Man is in fact said to be the only fisted creature on earth. Man also utilises his hands for the tasks of scratching and cleaning: four-footed animals only scratch with their back-foot, monkeys and apes can use either front or back limbs, whereas Man of course uses only the fore-limb for this purpose. The human hand also takes on the function of a tactile organ from the whiskers on the snout associated with lower animals.

The upright stance involves changes in the chest and in the mechanisms of respiration, changes which are necessary to meet the more active use which Man makes of his body. In four-footed animals muscular slings extend from the shoulder girdles; they help to support and transmit the body weight to the upper limbs and in so doing compress and flatten the lateral walls of the chest. In the orthogrades, however, the body weight has often to be supported by the arms during brachiation so that the chest now becomes flattened from front to back through compression by the anterior and posterior thoracic muscle layers. The sternum becomes fused into a single plate to strengthen the anterior chest wall against these greater stresses, the ribs and the muscles acting on them become modified, the contours of the diaphragm altered, while the anterior abdominal muscles, which in pronogrades extend over the whole of the front of the chest, become drawn downwards, losing their attachment to the upper 4 ribs. These changes lead to an alteration in the mechanism of respiration, — to an upper type of breathing with increased respiratory importance of the apical region of the lungs. Concomitantly the heart, which in quadrupeds comes in contact with the diaphragm only at its apex, becomes in bipedal animals firmly bound to the diaphragm; the diaphragm thus becomes attached to the lung roots via the heart, thus increasing the aeration of the lung apices.

The shape of the abdominal cavity seems to vary with posture. Four-footed monkeys have elongated loins and, as their chest is situated lower than their flanks, the abdominal organs tend to sag against the diaphragm. In bipedal forms, the loins shorten and the abdominal cavity widens from side to side becoming flattened antero-posteriorly; this affects the shape of the contained organs so that, for example, there is partial disappearance of the caudate lobe of the liver. In quadrupeds there is no compression of the abdominal organs because these animals are enclosed in a cylinder of spinal postural muscle from which fore- and hind-limbs act. In orthograde animals and even more so in Man, however, the arms no longer support the body and the thighs become entended so that the abdominal wall muscles now exert continuous and marked compression with a tendency to displacement of the abdominal organs; this is remedied by improved visceral support, namely more extensive peritoneal fixation and the suspension of viscera from the diaphragm as well as from the backbone.

The groin is a distinctive feature of Man's anatomy. Only in one animal, the gorilla, do we find a tendency towards its appearance. Its formation results from the extension of the iliac crests and the shortening of the anterior border of the ileum. In the male especially, its defence mechanism may occasionally be weakened giving rise to the formation of an inguinal hernia.

The erect posture also presents problems in the sphere of sex. Man and other orthograde animals walk erect so that their genital regions are more evident than they are in quadrupeds. Primates use the rear approach in mating during which the female genitals are visible to the male; the assumption of the erect posture and the consequent swinging of the vagina to the front has led Man to adopt the frontal approach. This could possibly explain the appearance of the secondary sexual characters, such as the beard, breasts, pubic hair, etc., on the

front of the body. Pronograde animals walking on all fours have their vaginal passage almost horizontal, but the erect human female walking bipedally has her vagina almost vertical; male seminal fluid deposited in it would therefore tend to gravitate out and be lost were it not for human orgasm which often leaves the female exhausted so that she has to lie horizontally for some time after intercourse.

Associated with the vertical posture, changes also occur in the nervous system. The centres of the mid-brain and cerebellum which regulate postural tone become more elaborated and the reflex centres in the spinal cord more coordinated. The vasomotor postural mechanism, which controls the distribution of blood, becomes specialised to allow blood to be propelled upwards against gravity, so ensuring a continuous supply to the brain. The stretch reflex also becomes more developed.

We finally come to the changes in the lower limbs, especially those in the foot: it is indeed the structure of the foot which mostly severs Man from all other existing primates.

The adoption of an erect posture brings the femur in line with the vertebral axis so that there is a more complete rotation of the hip joint (hence the permanent twist in the fibres of its capsule) as well as an increase in the size of the gluteal muscles. As the leg becomes more supporting in function it loses its power of pronation and supination, the rotator muscles of the tibia and fibula shifting their origin and becoming flexors and the fibula becoming markedly reduced.

But above all, changes occur in the foot. The anthropoid and the human foot are similar in structural composition and differ only in the arrangement and form of their components. The basic difference is that whereas the anthropoid foot has a free mobile great toe used as a grasping thumb, in Man the great toe becomes merged with the metatarsal series forming the part of a rigid supporting plantar arch. In the initial developmental stages the human and anthropoid foot are alike and it is only later that the great toe of the anthropoid foot attains a prehensile stage while that of the human foot retains its primitive adducted position. In the newborn the human foot, like the anthropoid one, is inverted and shows the same flexion lines on its sole: the human baby at first walks on the outer side of its feet and only later with eversion of the foot does the inner margin come to bear the weight of the body.

The prehensile foot has a 3 functional elements — tarsal, metatarsal and digital. The increase in weight of the body associated with the change from the small to the great anthropoid stage leads to an increase in length and strength of the supporting tarsal element while the metatarsal elements remain the same and the grasping digital elements shorten. In Man, the foot becomes modified as a "stepping-off" lever in progression so that the great toe element becomes even more predominant and the small toes even more reduced. There is no doubt that the best foot adapted for terrestrial progression is a foot of few digits, as evidenced by the horse which stands only on its third digit, and Man has come to rely mostly on his first digit, the great toe for this purpose.

In four-footed monkeys, the mid-tarsal joint is flexible to allow the heel to be raised while the great toe and digits retain their grasp. In the bipedal small anthropoids this joint becomes somewhat less flexible, while in the great anthropoids the joint allows of eversion and inversion though there is still no longitudinal plantar arch. This arch, which first appears in the gorilla, is due to the weight of the body being applied on the outer margin of the inverted foot so that the inner margin of the tarsus assumes a postural function. Continued inversion raises the inner margin of the tarsus and the metatarsal element of the great toe which soon becomes incorporated with those of the others so leading to the formation of a true longitudinal plantar arch: the grasping anthropoid foot is thus converted into the supporting human foot. The longitudinal plantar arch has great functional importance and its collapse, by a breakdown of the mid-tarsal joint, leads to the common condition of flat foot.

Muscular changes are associated with these skeletal ones. There is a change in the size and attachment of the muscles of the great toe but there is only one new muscle formed ,namely a second belly to the flexor hallucis brevis. There are also modifications in the insertion of the foot invertors, the appearance of a new evertor *(Peroneus tertius)*, while the plantaris become cut off from the plantar aponeurosis by the heel.

The human child attains its fully erect posture 14 to 15 months after birth — it usually stands unsupported by the age of 14 months and walks unaided at 15 months. Subsequent maintenance of a good erect posture is influenced by cultural aspects of training, background and environment. Posture is also to a large degree influenced by the inner emotions and it has been said that "we stand and move as we feel."

Man's upright posture brings with it certain serious mechanical drawbacks. I have already referred to the weakening of the pelvic floor with the possibility of prolapse, the breakdown in the defence mechanism of the groin with the formation of hernia, and the disruptions of the longitudinal plantar arch and the formation of flat-foot. I may also mention the possibility of dislocation of the base of the vertebral spine (spondylolisthesis), lateral curvature of the spine (scoliosis), drooping of the shoulders with pressure on the brachial plexus, and hallux valgus (the so-called "bunion" disease). To these must be added herniations of the intervertebral discs of the spine ("slipped d'sc") which often accounts for cases of so-called sciatica, lumbago and backpain.

The erect posture of Man marks him off from other animals, lifting him physically above the ground. It affords him improved and new forms of vision, the possibility of speech and gesture, above all manual dexterity.

Man's erect posture is in fact the symbol of his biological superiority.