Some Aspects of the Anatomy of Movement

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One is tempted to think of the anatomy of movement under the broad divisions of structures which are moved and those which move them: i.e. bones and joints over against the muscles and the nervous system. However, the character of movement depends as much on the arrangement of the parts which are to be moved as on the machinery available for moving them.

The locomotor system of the body is very often described as a system of bones united by joints which are moved by muscles under the control of the voluntary nervous system. To suggest amending this description and rather saying that the body is a system of joints maintained at the appropriate distances apart by bones may help us to remember that joints are not merely negative intervals between the ends of bones; the articulating ends of the bones and the structures connecting them constitute functional units.

Man and the Quadrupeds

The joint pattern of the human body is conditioned very largely by the fact that Man is an erect biped, using his lower limbs to support and propel the body and his upper limbs to explore and manipulate the world around him. This unique structural organisation, however, makes use of elements of basic structure shared also by quadrupeds. The quadrupedal body structure has been aptly pictured as a "walking bridge", the main portion of the vertebral column forming an arch between two pairs of supporting piers, with movable extensions at the head and tail ends. Each limb is divided into three movable segments alternately inclined forwards and backwards; in the fore-limb scapula, humerus, and forearm with hand, and in the hind-limb femur, tibia, and foot, the pelvic girdle, unlike the pectoral, being firmly incorporated with the vertebral arch (Martin, 1933-34). In each limb the first joint is a ball-and-socket joint, allowing sideways as well as forward and backward movement; the joints beyond this are essentially hinge joints permitting forward and backward movement only.

The Adaptation of Man

The adaptation of the human body to its upright posture has involved a long series of adjustments in the skeleton and joints: the counter-curves of the vertebral column, the very wide range of mobility of the shoulder girdle pivoting on the sternoclavicular joint, the postural extension of the elbow, hip and knee joints, and the unique construction of the foot as an arch resting on the heel and the metatarsal heads. The human limbs retain the primitive arrangement, discarded by the more highly specialised quadrupeds, for rotatory movements in their distal parts: pronation and supination in the forearm, inversion and eversion in the foot. Again, from the purely mechanical standpoint, the human foot can be regarded as a unit equivalent to the forearm and hand together, the heel being compared with the olecranon, and the joints between talus and calcaneum with those between radius and ulna (Grand, 1958).

The axial part of the human body can be thought of as composed of three major blocks, head, thorax and pelvis, united by two connecting links, the cervical and lumbar regions of the vertebral column. These linking segments are each composed of several articulating units, so that small individual movements add up to a considerable total. This arrangement, related to the function of the vertebral column as a protective case for the spinal cord, is achieved through a distinctive type of joint structure, the intervertebral disc, with its tough but pliable periphery and highly plastic central core.

Some joints may be considered intrinsically stable from the character of the articulating surfaces and joint structures, others as intrinsically unstable and held together only by muscular activity; the sacro-iliac joint may be taken as an extreme example of the former and the shoulder joint of the latter. The structural instability of the human shoulder joint has been accentuated by its increased range of mobility following its liberation from the function of supporting weight. The stabilising action of muscles in relation to joints is thus of equal importance with their function of producing active movement.

The Functional Division of Muscles and their Nerve Supply

The functional division of the muscles as well as their nerve supply rests upon the basis of an original longitudinal segmentation of the body. Each segment comprises primarily a posterior muscle mass behind the spinal cord, and an anterior mass extending from the front of the vertebral column around the flank to the ventral body wall; these are supplied respectively by the anterior and posterior primary divisions of the segmental nerves. In certain segments the anterior muscle mass is further called on to produce the limb muscles, which are at first divided into a dorsal extensor and a ventral flexor mass, supplied by the anterior and posterior divisions of the nerve plexuses. The segmental pattern has been greatly obscured, not only by fragmentation of the segmental units and fusion of adjacent segments, but also by the twisting of the limbs in opposite directions, so that the original upper surface faces backwards in the upper limb and mainly forwards in the lower limb, and still further by the enormous expansion of the muscles linking the upper limb to the trunk, which have completely enveloped the true back muscles as well as those of the upper part of the thorax.

"Spurt" and "Shunt" Muscles

The many different arrangements of the fibres in individual muscles can be reduced to two basic patterns. One has the fibres directed longitudinally, so that the full extent of their contraction can be registered as movement; the other has them directed obliquely, so that part of their contractile length is lost, but their number is increased providing additional power. Another noteworthy distinction (MacConaill, 1949) is between those muscles which pull across the angle of a joint ("spurt" muscles) and those which always remain parallel to the moving bone ("shunt" muscles); the proposition that the former are essential initiators of movement, while the latter act as synergists once movement has been initiated, seems to be supported by electromyographic evidence (Basmajian, 1959).

The Motor System

Voluntary, willed movement depends on the integrity of the pyramidal tract from the "motor" area of the cerebral cortex to its contacts with the motor nerve cells of the brainstem and spinal cord. The pyramidal system, however, cannot function in isolation. It is dependent both on the inflow to the cerebral cortex of sensory impulses, particularly those arising in the locomotor system itself, as well as those of orientation and balance arising in the labyrinth of the internal ear, and on the collaboration of the series of descending fibre-connections bracketed together as the extra-pyramidal motor system, originating partly in the cerebral cortex, partly in the basal ganglia, and partly in the reticular formation of the brainstem.

The extra-pyramidal motor system is as much dependent as the pyramidal system on the inflow of sensory information, not only that reaching the cerebral cortex, but even more that directed to the cerebellum. In particular, there is a clear relation between the cerebellar connections of the sensory and extra-pyramidal motor systems and the anti-gravity postural responses of the locomotor system. Furthermore in the human brain the cerebral cortex, the basal ganglia, the reticular formation, and the cerebellum are

ORDER OUT OF CHAOS

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"And the Earth was without form and void—
and the Spirit of God moved."

In other words order emerged from chaos.

I am not going to tell you anything new, anything you do not already know. I am going to ask you, with me, to think over some of the basic principles we all learnt as students. I humbly suggest that in the rush and bustle of our clinical work we may have forgotten and discarded some useful and important concepts—or at least we have not developed and used them with all the thought and skill in our power.

The definitions of "move" in Chamber's Dictionary are many—here are some of them. "To impel, to excite to action, to persuade, to instigate, to arouse, to live one's life". All germane to what we think about and how we act in teaching our patients to move. Perhaps the most pertinent of all, the last one "to live one's life".

As Physiotherapists isn't our most important aim in all our treatments to restore "order" in movement that has become "chaotic"—chaotic due to pain, limited range, loss of muscle power and neuro-muscular co-ordination?

We have heard from Professor Wells and Professor Stammers something of the anatomical physiological background of the ordered movement, and from Professor Allen a challenging lecture on its importance. But is not this restoration of ordered movement our own greatest contribution to rehabilitation, provided it takes into account the "whole person".

In the creation of the Universe, and in it this World, is not man the highest created being and is not his gift of free will the most precious gift with which he has been endowed? So in our humble efforts to restore order to a disorganised chaotic motor system, should not our foremost aim (by arousing, exciting to action, and persuading) be to enlist the patient's free will, and help him to direct it towards his return to normal ordered bodily function—to live his own life? This brings me to my first point:

Bring in the patient—not just literally but in every sense of the word. Psychologically and physiologically he will benefit most if he co-operates as fully as possible in his rehabilitation programme.

Psychologically how dangerous dependence on another's efforts can be. How restricting to the whole concept of rehabilitation is just the alleviation of pain or even, to take an extreme example, maintenance of muscle and joint by electrical means and passive movements only: passive movements performed by the physiotherapist without making the patient "think" the movement as it is done for him. This thinking the movement at once brings him into the picture, and as we all know is physiological commonsense in that it helps to maintain the memory pattern. The idea of that movement is kept alive by making the patient realise the afferents from muscle tendon and joint as the pattern is performed. Psychologically it is common sense as he is automatically participating in this initial activity and is therefore realising that he has to do something himself to effect his own cure.

Media for Movement—Water or dry land. Water will be dealt with by Mr. Nicol.

Manual or Mechanical—Dry land treatments by movement will include the use of manual and mechanical assistance or resistance. Both have advantages and disadvantages as you very well know. We are all aware of the danger of using mechanical aids to movement, meaning specifically mechanical assistance with springs or weights. We know the danger of over-stretching tissues if the aid cannot be fully controlled, or the danger of repetitive irritating movements using suspension or bilateral pulleys—yet in selected cases they can be most valuable as they may provide a means of enabling the patient to work *on his own*, i.e. without the obvious assistance of the physiotherapist, when without the sling or pulley or spring he could do little or nothing at all.

Manual assistance or resistance is sometimes better than mechanical means. It is sensitive and adaptable to the changing states of tension, spasm or inco-ordination in the neuro-muscular mechanism, and can therefore more readily be adapted to meet these changes. On the other hand too much manual handling can be psychologically undesirable, leading to dependence of the patient on the physiotherapist.

Mechanical means can be arranged and worked by the patient himself, even at home. They are time-saving for the physiotherapist, whereas manual techniques are time-consuming. Perhaps the greatest danger of all in using mechanical apparatus is that it can become too automatic and lack the essence of truly "live movement". But again, if scientifically arranged with due regard to mechanical and physiological principles, the great advantage of using weights, for example, is that progress can be graded accurately and the patient can often treat himself at home.

Group of Individual—Which will suit this patient best? Quite likely he will benefit by some of each. We are apt to think we cannot give group treatments if we have no gymnasium. I sometimes think a gymnasium is a bad thing in a department. It tends to be set apart as a separate entity rather than being the central core of the whole set-up. Actually a round department with cubicles at the periphery and central space with some exercise equipment could be a very good plan! However, if we are really group minded, group treatments can be given, even if the department or clinic will only hold two patients and the physiotherapist. Organisation of like type of cases at the same time for other

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linked together by a complex system of interconnections, by means of which, it is assumed, the cerebral cortex establishes a predominance over the other components of the brain. Consequently the results of anatomical and physiological studies on simpler type of animal brain cannot necessarily be applied to the much more complexly organised human brain.

References

General:

Barnett, C. H., Davies, D.V., and MacConaill, M. A. (1961. *Synovial Joints. Their Structure and Mechanics.* London: Longmans, Green and Co. xi + 304 pp.

Chusid, J. G. and McDonald, J. T. (1960). *Correlative Neuroanatomy and Functional Neurology.* 10th ed. Los Altos, Cal.: Lange Medical Publications, 360 pp.

le Gros Clark, W. E. (1952). *The Tissues of the Body.* 3rd ed. Oxford: Clarendon Press, xi + 407 pp.

Particular:

Basmajian, J. V. (1959). "Spurt" and "shunt" muscles: an elecromyographic confirmation. *J. Anat. Lond.*, Vol. 93, pp. 551-3.

Grant, J. C. B. (1958). *A Method of Anatomy.* 6th ed. Baltimore: Williams and Wilkins. xxv + 879 pp.

MacConaill, M. A. (1949). The movements of bones and joints. 2. Function of the musculature. *J. Bone Jt. Surg.* Vol. 31B, pp. 100-104.

Martin, C. P. (1933-34). A comparison of the joints of the arm and leg and the significance of the structural differences between them. *J. Anat. Lond.*, Vol. 68, pp. 511-520.