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PART II

THOUGHTS ABOUT THE MEASUREMENTS OF MUSCLE TONE

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INTRODUCTION

THE subject of tone has been discussed for many ages and there is a great deal of literature on it. It is impossible to give a survey of this literature although it might be of histological importance. In current literature on muscle tone we often meet the names of Brondgeest, Sherrington, Granit and recently some of the work of the Russian physiologist Bernstein has been made available in the English language. On the basis of some books of these physiologists some thoughts will be formulated on the measuring of muscle tone.

In a time when nearly everybody was becoming convinced of the fact that muscle tone was independent of the activity of the spinal cord Brondgeest in 1860 showed in an extremely fine way that this was not correct. He found out that it was simply impossible to observe both hind legs of a frog at the moment of cutting a nerve and, at that same moment, see whether there was any difference in posture, which is what Heidenhain had tried to show before him. Therefore Brondgeest waited long enough after the cutting and found the difference! He explains the meaning of tone in those days as follows: 'The organs directly influenced by means of the nerves and nerve-centres and the state of which is of great importance for our knowledge about them are the muscles. From their activity one has been able to conclude that there is a nerve-centre which rules the voluntary movement: the brain'.

Another centre, activating involuntarily and separately from the brain, is the spinal cord. Under the influence of one's will at intervals only those activities emanate from the brain which cause the muscle to contract temporarily.

Is this also the case with the spinal cord, or rather is there a continuous activity in such a way that as soon as the muscle contracts by one's will the already existing activity in the grey matter of the spinal cord is only increased or changed?

Should this be the case then, without the influence of one's will, the muscles too will have to be in a slight state of lasting contraction under the influence of the spinal cord. This state of lasting contraction has, by our modern physiology, been called 'the tone of the voluntary muscles'. Brondgeest's experiments were done on frogs with a transection of the cord, either just below or above the cervical region. On both sides he exposed the Ischiadic nerve, which was cut only on one side.

With 62 frogs prepared in that way, he found a difference of posture in the two hind legs. The posture of the limb with the intact nerve showed a somewhat

more bent position than the limb in which he had cut the nerve and this difference he could measure. As a conclusion of his experiments on 62 frogs Brondgeest stated: 'There is a lasting contraction of the muscles as long as these are connected with the cord by means of the nerves'.

Brondgeest also studied reflex actions with his animals. He noticed that the leg on the side with the intact nerve bent a little more after a soft pressure of a toe, also that this situation lasted very often for more than half an hour. After pinching, the leg was even bent against the body. He also described reactions after stimulation with cold, heat and sulphuric acid.

One could say he did experiments to elicit the flexion reflex, but didn't describe whether a different tone existed in a more contracted posture. Brondgeest even managed to cut the dorsal root without damaging the cord in his preparations. After doing this with 20 frogs he couldn't elicit the reflex actions any longer and concluded from this:

1. There is a tone of the voluntary muscles, which means that these muscles, separated from the brain, are in a state of lasting contraction as a result of a continuous activity of the nerve-centres and from there on to the muscles through the nerves.

2. The existence of this tone depends on the uninjured state of the sensory nerves. As long as the spinal cord is influenced by sensory nerves an activity in the motor-centres is being kept up, which produces the lasting contraction called tone.

So the tone of the voluntary muscles is a reflex tone. If the sensory nerves have been cut and the possibility of reflex activity has been abolished; tone has disappeared. According to the description of Brondgeest the patient with the total cervical cord lesion for instance should show the muscle tone he described.

As we know, these patients do show reflex activities as described by him. And the question is, how to measure their tone? We did try this by means of electrical stimulation and the myograph. Electrical stimulation was chosen because one can exactly measure the strength of the electrical stimulus (Pool, 1965, 1966).

Two needles were inserted under the sole of the foot and two electrodes were inserted into the m. rectus femoris which, according to Kugelberg C. s. (1960), takes part in the flexion action of the leg. On inserting the needles and the electrodes a strong flexion action is observed. After that no myographic activity can be seen or heard. The Brondgeest tone doesn't seem to give a myographic response, at least not in our experiments with the rectus femoris.

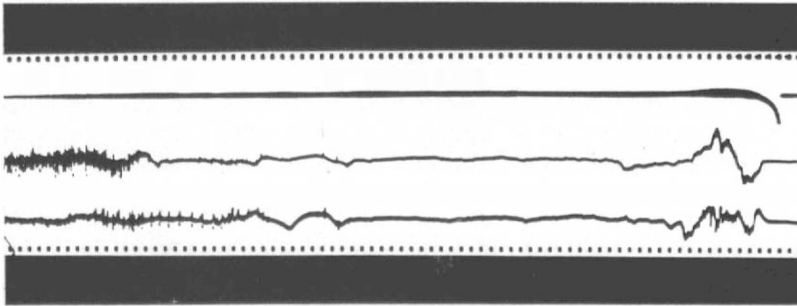
There was however a myographic activity during the flexion action after stimulation with sufficient strength and a second burst of action potential was noted on the returning of the leg to the rest position (see Figure). As the first burst is probably due to the flexion action, the second one is not seen until the leg returns to the rest position and is probably due to the stretch reflex. With this experiment the same strength of electrical stimulus was needed with a patient with a total cervical lesion as with a control person. The patient however also reacts to a very slight stimulation, as for instance blowing along the skin of the foot, which a normal person easily inhibits. Should one consider these bursts as disturbances of the Brondgeest tone or as a part of this tone?

Brondgeest stated: In case the reflex activity has been abolished, tone has disappeared. If this is correct, Brondgeest also meant to show that movements

are possible reflex of origin without interplay of the brain but dependent on the influence of the peripheral nerve. Therefore he probably called his tone reflex tone.

According to Granit, Sherrington arrived at the same conclusion as Brondageest did with regard to muscle tone. Sherrington's favourite preparation was the cat. He made his transection in the brain stem between the corpora quadrigemina and, according to Granit, left the gamma system intact and got that curious state called decerebrate rigidity. He could bring about changes in that situation by stimulation of the skin and in that way he could examine reflex patterns.

Granit writes: 'In the end, Sherrington came to the final conclusion, generally accepted in his lifetime, that tone was a postural reflex, a view that arose from his work on decerebrate rigidity and the finding that this state of exaggerated tone disappeared after dorsal root section and hence originated in a sense organ'. Does this imply that in the case of decerebrate rigidity another tone is meant than Brondageest indicated? Sherrington, himself, probably also had some difficulty with the term tone, which appears from his statement on a conference in Berne:



'The term tone, speaking of its origin, comes to us from a time when the doctrine of its existence or non-existence was almost an article of faith. Then later, for many years, it stood for a general condition of slight tension rather mysteriously obtaining in all healthy muscles at all times, a somewhat elusive property: how far peripheral or central, and whether reflex or not, was answered differently by different observers'. Granit concludes in 1966: 'Tone can still be called a somewhat elusive property'.

In tone many functions, nervous as well as muscular, are organised for co-operation and the best we can do is to study them one by one as well as when they are acting in co-ordination. The problem of tone involves circuit analysis rather than the study of reflexes alone. A situation with strong postural reflexes, comparable with the decerebrate rigidity, is probably that of spastic children. With them the active movements have to conquer a strong resistance.

Kenney and Heaberlin (1962) made a comparative study of spastic and normal children and found that the spastic child had to conquer a 'built-in' resistance with his muscle performances. According to them this 'built-in' resistance is caused by the stretch-reflex.

Can the brain affect the peripheral reactions? Kugelberg C. (1958) proved this with abdominal skin reflexes, which are muscle reactions to stimuli of the skin. In this manner we know many skin reflexes. We also know muscle reactions caused by a shortening of a muscle.

The P.T.R. is an example of this. It is a stretch reflex or postural reflex. This reflex, too, can be affected cerebrally as Granit C. (1953) has shown. The skin itself reacts to stimuli by its circulation. In this way we know skin reactions to stimuli of temperature, mechanical stimuli etc. These reactions are attributed to the sympathetic system, a system that also can be influenced by our brain. Flushing and the faster beating of the heart, for instance, are attributed to it. Our cerebrum is obviously able to influence peripheral reactions. Does this change our tone problem?

This question is answered by Bernstein.

- (a) Tone as an ongoing physiological adaptation and organisation of the periphery is not a condition of elasticity but a condition of readiness.
- (b) Tone is not merely a condition of the muscles but of the entire neuromuscular apparatus.
- (c) Tone, from this point of view, is related to co-ordination as a pre-condition is to an effect.

According to Bernstein not a single case of pathological co-ordination is known in which there is not at the same time a pathology of tone and not a single central nervous apparatus is known which is related to one of these functions without being related to the other. Co-ordination helps us to overcome peripheral indeterminacy. Improvement in co-ordination is achieved by utilising all possible methods to reduce the number of degrees of freedom at the periphery to a minimum.

Going back to the original definition of Brondgeest, Bernstein seems to have added only a few words to it. Brondgeest stated that the existence of tone is connected closely to the uninjured condition of the sensory nerves. We now know that a nerve consists of different fibres of different sizes and a different velocity and probably a different function. One could say Bernstein changed Brondgeest's definition into: The existence of tone is closely connected with an uninjured condition of all the fibres of the peripheral nerve and consequently with all the qualities of the peripheral nerve and of the entire neuromuscular apparatus. If we describe tone in this manner then what we would like to measure is probably the lack of tone, which we observe as a resistance or a restricted freedom of movement.

Bernstein states that co-ordination develops slowly and as a result of experience and exercise, which gradually develops a greater economy of movement and a diminution of fatigue. According to this a measurement of tone is possible in the measurement of the speed of an action or an increase in endurance. Taking the walking action of spastic children as an example, one observes, indeed, an improvement in speed and performance with regular training, which means improvement in tone, according to Bernstein.

Thoughts about the measurement of muscle tone was chosen as the title of this paper because after ages of publications on the subject we can only think about it. At present it seems we have nearly passed the time of studying reflexes on animals with a transection of the cord. We now enter into new possibilities of research; a new period in which the entire animal and the entire person is studied. Our problem today is how does our patient as a whole subject react to situations with his tone? This is equally the case with the patient who suffered damage of his spinal cord.

As a conclusion one can only hope that the statement of Granit in his book

entitled *Charles Scott Sherrington: An appraisal*, 'In the end, understanding of the principles which physiology is now beginning to unravel must also become useful in clinical work', will come true.

ZUSAMMENFASSUNG

Das Problem des Muskeltonus und seine Messung wird diskutiert. Die Wichtigkeit, den ganzen Patienten zu studieren, wird betont.

Eine Möglichkeit der Tonusmessung ist die Bestimmung der Aktionsgeschwindigkeit und Ausdauerzunahme.

RÉSUMÉ

Le problème du tonus musculaire et de sa mesure est discuté. Il est important d'étudier le malade dans son ensemble.

La vitesse de l'action et l'augmentation de l'endurance serait utiles à étudier.

SUMMARY

The problem of muscle tone and its measurement is discussed. The importance of studying the patient as a whole subject is stressed. A possibility of muscle tone measurement is probably the measurement of the speed of an action and an increase in endurance.

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MANAGEMENT OF PATIENTS WITH MYELOMENINGOCELE

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THIS study is concerned with the neuro-orthopaedic study, urological management and educational orientation of 74 patients with myelomeningocele. The ages of the patients studied range from 2 to 25 years (50 per cent. from 7 to 14).

The neuro-orthopaedic study includes 56 patients who have been divided into 5 groups according to the level of the lesions as follows:

Group 1: above T ₁₂	2 patients
Group 2: L ₁ -L ₂	17 patients
Group 3: L ₃ -L ₄	24 patients
Group 4: L ₅ -S ₁	12 patients
Group 5: S ₂ -S ₃	1 patient