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Gamma-spindle loop in man

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RESUMEN

El autor se plantea la coactivación alfa-gamma y el papel de la sensibilización de los husos por la inervación gamma tanto en condiciones de normalidad, como en la espasticidad, como en la rigidez. En el campo experimental recuerda la diferencia entre la rigidez de descerebración clásica, por hiperactividad gamma, y la rigidez alfa. Insiste sobre el valor del estudio de un reflejo miotático "descargado" *(unloading)* y sobre el fruto que puede obtenerse también de estudiar los efectos de su carga brusca o de sobrecargarlo en un momento dado.

The stretch reflex has long been a diagnostic tool, its phasic component in the knee jerk, its tonic variety in relation to postural reflexes. Its permanent actuality is demonstrated also by the Tokyo Symposium in 1975 (Homma, 1976) entitled "Understanding the stretch reflex". Understanding the role of the gamma loop in these reflexes is a clinical necessity. The gamma motor fibres, so often linked in coactivation with the alpha motor fibres, serve but one task; they sensitize the spindles. Consequently the first question will alway be: under what conditions does this sensitization of the spindles operate? The next step is likely to be: is it possible to ascribe to the gamma-loop in action any specific clinical abnormality, disease or symptom?

The same questions have also been raised by physiologists working mostly on cats. One answer was obtained at an early date (see my summary 1955): though several factors combine to produce the state of decerebrate rigidity, gamma hyperactivity adds a decisive component. Already at that time it was perfectly clear that states of pure alpha hyperactivity were responsible for another type of rigidity. Pathological states in man may well have certain features in common with the two types of rigidity in the cat but the latter can neither be reproduced in man nor be thoroughly analyzed if perchance they happened to occur.

The best evidence of spindle activity under gamma control in man has come from the micro-

neurographical technique introduced by Hagbarth and Vallbo (1969) and has involved voluntary control of muscles in action. Both authors have recently published independent summaries of their experiences with this technique up to the present time (Hagbarth (1981), Vallbo (1981)). The most general rule found in these experiments states that there is coactivation of intra- and 'extrafusal' muscles by alpha-gamma linkage (the latter term held by myself to imply an anatomical link), rise of tension in the muscle slightly preceding the spindle discharge. Interpretation of this message to the nervous system will take place at many central stations but of this very little definite is known. We assume sensory feedback to be important but cannot exclude parallel contributions from skin and joint afferents. Only on the motor effects of the coactivated discharge can something be said because of the existence of monosynaptic projections on the motoneurons of the loop. On them there will be facilitation or disfacilitation dependent on the variations in the firing rate of the spindles.

Using microneurography in attempts to confirm or disprove findings, based on H-reflexes, on spastic and rigid patients, Hagbarth (1974) concludes that spasticities do not differ from normals in relative amount of gamma control but that in patients with Parkinsonian rigidity "the muscle hypertonia seems to be accompanied by a sustained spindle discharge similar to that accompanying weak or moderate sustained voluntary contractions in healthy subjects".

Microneurography has limitations regarded as an allround technique for hunting for pathological states of gamma hyper- or hypo-activity. It can only be used by specialists, on one muscle at a time, and the electrode is easily dislodged by strong contractions. The Australian group (Westerman, Burke et al., 1981) has tried to evaluate what they call the flexibility of the relation between the two motor systems when activated under a large number of different conditions. The threshold of spindle activation was the best index and it seems promising that it could be lowered by caloric vestibular stimulation, known to be a potent governor of the gamma motoneurons in the cat (Carli, Diete-Spiff and Pompeiano, 1967).

However, there remains the question of whether any other method exists that could be used in a search for pathological behaviour of the spindles of man? *One* might be the so-called unloading reflex. If a voluntarily held weight suddenly is released there will be a pause in the EMG if the spindles contributed to the contraction. This experiment could be arranged as an exchange of a heavy weight for a lighter one so as to maintain EMG activity. At least in strong isometric contractions the spindles should add a substantial amount to it. Now, when we know that the spindles are coactivated in such contractions, it would seem worth while systematizing experiments on unloading.

What about unexpected loading? There are several experimental papers dealing with this problem but it requires a considerable amount of technical skill and more machinery than is feasible for a routine test in the clinic. Elsewhere I have discussed the possibility of making use of 'constant errors' to study spindle activity (Granit, 1972). There is an old experiment by Hollingworth (1909) that perhaps could be developed into something useful. Subjects were quickly trained to pull a carriage along a track, 1, 2 or 3 feet. If this were done at a slow speed the spindles would be coactivated and add their contribution to judging the distance to whatever arrived from other receptors in skin and joints. Hollingworth found that the distance was judged quite accurately but that if a stop unexpectedly was introduced by a momentarily inserted upright, the length of the track was misjudged by as much as 155 per cent of the standard. The sudden transition from isotonic to isometric activity would necessarily mobilize the spindles. This in turn would add an unexpected facilitation of the motoneurones forcing them to go on firing beyond the distance prescribed. This constant error could not be abolished by training. The error was reduced by inserting the upright late in the movement. One would expect coactivation to be counteracted by the isotonic shortening of the muscle, as bending the arm approaches the end of the movement along the track. The idea of this experiment seems sound but, just as the previous, suggestion it need be carefully investigated.

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