TONIC REFLEXES IN MAN

COMMUNICATION III. TONIC CERVICAL REFLEXES IN HEALTHY ADULTS AND THE INFLUENCE OF UNSTABLE POSITION ON THESE REFLEXES

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Among tonic reflexes an important part is played by reflexes from cervical muscle (or vertebro-cranial articulation [10]) proprioceptors when the position of the head is altered with respect to that of the trunk. R. Magnus [9] established that these reflexes were also important in the system of static and of static-kinetic reflexes and also demonstrated their close interrelation with labyrinthine and proprioceptive trunk reflexes. I. S. Beritov [1] concluded that the impulses from the cervical and labyrinthine receptors were in themselves too weak to elicit a reflex but enhanced the excitability of centers which coordinate these reflexes,so that activity occurred whenever some additional stimulus was brought into play. There have been many attempts at detecting these reflexes in man. They were observed in clinical practise by M. Minkowski [11], H. Stenvers [13], P. Simons [12]. Krol', Markov and Kantor [7] observed diminution of chronaxie in the forearm extensors on the "chin" side when the head was turned to the side and interpreted this as indication of increased tone; their subjects were healthy adults. A. N. Krestovnikov [5] also observed healthy adults, using the roentgenokymograph method, and obtained increased diaphragm tone on the "chin" side and decreased tone on the opposite side.

Our aim was to investigate the changes in tone on altering the position of the head in healthy people (cervical tonic reflexes) and the effect of unstable body posture on these reflexes.

EXPERIMENTAL METHOD

Experiments were performed on healthy adults (students of the Institute of Physical Culture) who took part in sports but were not training during recuperation from some somatic disorders. The degree of muscle tone was measured by the O. V. Plotnikova and I. I. Shaffer [8] tonometer. Changes in muscle tension were recorded graphically by myotonography [3, 4] from both deltoid muscles; these records were taken in the sitting position with hands folded in lap and in the "standing at ease" position. Myographic records were also taken of the "voluntary" tension of both pectoralis major muscles on changing the position of the head at a command from the experimenter and the involuntary reflex change in tone in both deltoid muscles.

EXPERIMENTAL RESULTS

Cervical tonic reflexes are detected myotonographically as slight but definite increases in the tension of the deltoid muscle contralateral to the side toward which the head is inclined. In some cases diminished muscle tone was noted in the ipsilateral deltoid at the time when the tone was increased in the deltoid contralateral to the direction in which the head was inclined. Inclination of the head backward increased the tone of both muscles, while inclination forward most frequently decreased the tone of both muscles, but sometimes increased it somewhat or produced no change. Turning the head to the side increased the muscle tone bilaterally but more so on

the ipsilateral side (Fig. 1). The myotonogram shows clearly the difference between the high, steeply rising and falling "voluntary" tension of the pectoralis major muscles and the low, slowly rising tonic reflex tension of the deltoid muscles.

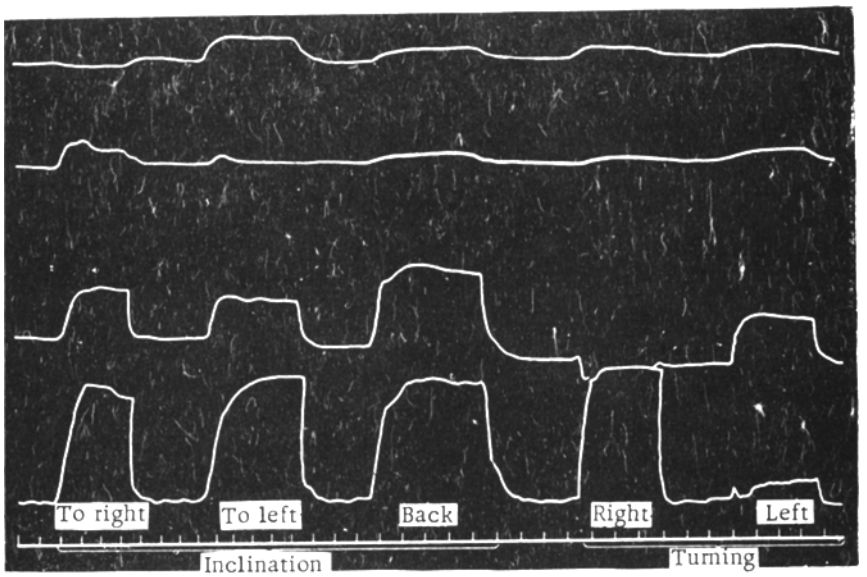

Fig. 1. Myotonograms of both pectoralis major muscles and deltoid muscles in subject N.K., male, 23 years old. Standing "at ease" position; various changes in the position of the head (in the following order: inclination to the right, left, back, turning to the right, left).
Records from above down: right deltoid, left deltoid, right pectoralis major, left pectoralis major muscle; time marker (1 second).

Tonometric data were in complete accord with this. The greatest difference compared to the initial position of the head was noted when the head was inclined sideways and backward reaching +10 - 12 mm Hg in adults, corresponding to 33% of the initial background.

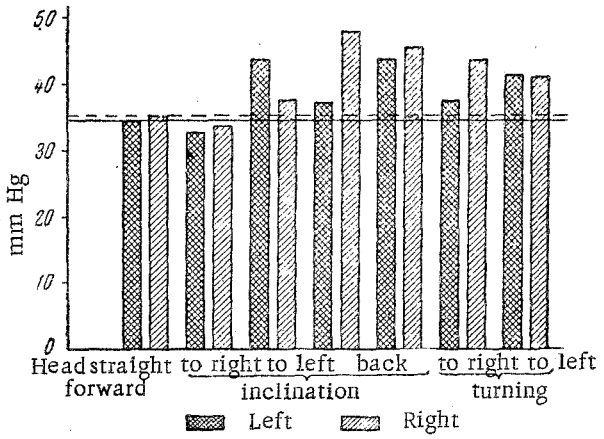

Fig. 2. Diagram of tonometric data for both deltoid muscles in subject A.M., 22-year-old male, during different positions of the head.
Ordinate: values of muscle tension in millimeters of mercury. Initial level (with the head held straight) denoted by a solid line (for the left deltoid muscle) and a broken line (for the right deltoid muscle).

The diagram presented in Fig. 2 can serve as an illustration. It must be noted that these reflexes are more marked in subjects who are not undergoing systematic physical training. Those who are undergoing such training show much smaller reflexes and only when the head is inclined sideways. Such positions are almost nonexistent in exercises and we suppose that cervical tonic reflexes are preserved in such subjects for the very reason that they are unusual. It appears that in all the other positions which are common in athletics the conditioned reflex inhibition suppresses the cervical tonic reflexes.

The main significance of tonic reflexes lies in their contribution to preservation of balance. Body balance is very unstable, viewed from the standpoint of mechanics, but human adults maintain their balance very well physiologically in a great variety of positions. This must evidently be ascribed to perfection of the

mechanism of unconditioned and conditioned tonic reflexes. The course followed by tonic reflexes under various conditions of equilibrium is thus of great interest.*

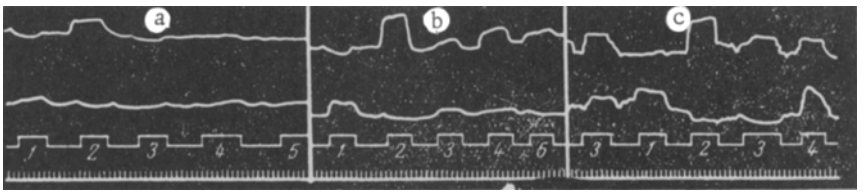

Fig. 3. Myotonograms of the deltoid muscles: a) in the sitting position; b) in the standing position; c) standing on a springy rubber membrane. Records from above down: right deltoid muscle, left deltoid muscle, marker showing changes in position of the head: 1) inclination to the right; 2) inclination to the left; 3) inclination backward; 4) turning to the right; 5) turning to the left; time marker (1 second).

We therefore repeated the studies on cervical tonic reflexes in a single experiment including some of the 5 different positions of the body: I – sitting, II – standing "at ease," III – standing "at ease" with eyes closed, IV – standing on a springy rubber membrane, V – standing on a springy rubber membrane with eyes closed (this position was only used in the case of subjects with good balance preservation). Objective recording in these experiments was only monitored by myotonographic records [5, 8] from the two deltoid muscles.

When the subject changed from one position to another with progressively more difficult conditions for maintaining his balance there was growing increase of cervical tonic reflexes. A typical case was that of subject A. M. (male, 22 years old). Fig. 3, a shows the myotonogram recorded in position I (sitting, hands folded in lap). The tonic reflexes are small; well-defined increase of tone was only noted on the contralateral side when the head is inclined sideways. Reflexes increase markedly when the subject is made to assume position II (Fig. 3, b). The most marked change is seen in the right deltoid muscle. Inclinations sideways are accompanied by simultaneous increase of tone contralaterally and definite decrease of tone ipsilaterally; inclination of the head backward is associated with a small bilateral increase of tone. Position III causes an increase in tone in many subjects but evokes tremor more frequently and sometimes differs little from position II. Very characteristic are the phenomena arising in position IV (Fig. 3, c). It is associated with very pronounced tremor, occasionally with loss of balance: the subject raises his arms, makes a step and even jumps off the rubber. The reflexes are pronounced. Fig. 3, c) draws attention not only to the marked increase of reflexes and tremor but also to the generally unstable level of tonic tension as reflected in the fluctuations of the traces for the right and left deltoid muscles which had been sufficiently stable as can be seen from Fig. 3, a.

The influence of unstable position on the cervical tonic reflexes varies, depending on the physical training of the subjects. The picture described above applies to persons who are not engaged in sports or athletics. Those who are so engaged, and especially athletes and acrobats, are continuously exercising their ability to maintain body balance in very complex positions and therefore exhibit less marked changes in reflexes on changing the position of the body. An additional position V – standing on the rubber with eyes closed – was used for trained athletes. This position is sustained with difficulty even by first-rate athletes, causing loss of balance and performance of balancing movements. It is particularly difficult to maintain balance when inclining the head backwards; this causes not only tonic but also phasic contractions of the muscles and gross movements of the whole body. Consequently, the cervical tonic reflexes become more apparent as the conditions become more unfavorable for preservation of balance; the reason for this is evidently that in a new and particularly in an unaccustomed position of the body (on the rubber sheet) the unconditioned reflex regulation of tone resumes an important role, and the cervical tonic reflexes are a component of this regulation. When trained athletes and acrobats are subjected to the most complex conditions and the tonic reflexes become weaker – always accompanied by increased general tension of muscles – it evidently indicates that in such cases the previous formation of appropriate natural conditioned reflexes transfers the function of balance preservation to the cerebral cortex which sends increased impulses to the body

* The influence of unstable position on the proprioceptive reflex described by A. A. Ukhtomskii has already been investigated in our laboratory by A. S. Dmitriev [2].

musculature and balance is maintained by diffuse tension of the muscles.

This fact confirms the earlier findings of A. N. Krestovnikov [6] that the role of proprioceptive sensation increased when the body found itself without support or inadequately supported. It follows that both in life, and under conditions of physiologic experiment, increasing difficulty in maintaining equilibrium leads to increased importance of the cervical tonic reflexes. As regards the mechanism of this phenomenon, it may be supposed that the direct cause responsible for the lowering of the cervical tonic reflex threshold, upon impairment of balance, is excitation of the vestibular analyzor receptors.

SUMMARY

The cervical tonic reflexes were investigated on deltoid muscles of healthy persons. Myotonographic and tonometric methods were used. It was revealed that when the head was bent backward , the tone increased on both sides, when the head was bent to one side the tone increased on the opposite side, whereas when the head was turned, the tone increased on both sides with the prevalence on the side to which it was turned. The reflexes were more pronounced in untrained persons and less so in trained athletes. The reflexes were considerably increased when the body was in an unstable position.

LITERATURE CITED

[1] I. S. Beritov, Izv. Ross. Akad. Nauk 649 (1915).

[2] A. S. Dmitriev, Biull. Eksptl. Biol. i Med. 45, No. 3, 38-40 (1958).*

[3] E. P. Kesareva, Teoriia i Prakt. Fizich. Kultury No. 5, 368 (1955).

[4] E. P. Kesareva, Fiziol. Zhur. SSSR 43, No. 8 (1957).

[5] A. N. Krestovnikov, Fiziol. Zhur. SSSR 24, No. 4, 757 (1938).

[6] A. N. Krestovnikov, Uchen. Zapiski Inst. Fizich. Kultury im. Lesgafta No. 3, 26 (1949).

[7] M. B. Krol', D. A. Markov and N. G. Kantor, Zhur. Nevropatol. i Psikhiat. No. 8, 19 (1931).

[8] O. V. Plotnikova and I. I. Shaffer, Fiziol. Zhur. SSSR 40, No. 4, 495 (1954).

[9] R. Magnus, Körperstellung, 1924.

[10] G. P. McCouch, I. D. Deering and T. H. Ling, Journ. of Neurophysiol., 1951, v. 14, p. 191.

[11] M. Minkowski cited by R. Magnus.

[12] P. Simons, Ztschr. f. d. ges. Neurol. u. Psychiat., 1923, Bd. 80, S. 499.

[13] H. Stenvers, Arch. neerland. de physiol. de l'homme et des anim., 1918, v. 2, p. 669.

* Original Russian pagination. See C. B. translation.