POSTURAL AND LOCAL COMPONENTS IN THE CONDITIONED LEG-RAISING REFLEX IN MAN

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny,
Vol. 53, No. 6, pp. 6-11, June 1962
Original article submitted April 21, 1961

Many workers [2, 3, 5] have shown that the conditioned leg-raising reflex consists, in its effector part, of two components. In the first place there is a displacement of the general center of gravity of the body (the postural component), which leads to the establishment of a new posture. This results in a local movement of elevation of the lower limb (the local component). Investigations on the dog [3, 4] have shown that when a collapse of higher nervous activity occurs, with the development of fatigue, and also during the first stage of formation of differentiation, in the first place the rate of development of the postural component begins to slow down, and then the local component is similarly affected.

The greater sensitivity of the postural index suggests that it may be used as a method of investigation of both components in clinical and physiotherapeutic practice. As a first step in the investigation an account must be given of the most general features of these components of the conditioned reflex in the apparently healthy subject. The present paper is devoted to this purpose.

EXPERIMENTAL METHOD

The technique has already been described elsewhere [4]. It consists essentially as follows. With his body weight uniformly distributed between both lower limbs, the subject stands on two small platforms of the apparatus which record changes in the pressure during the action of raising the leg. The duration of the local movement is recorded by making and breaking an electric circuit. The identification point for recording this movement is the distal part of the thigh, bordering on the patella. The length of the path of registration of this point is 24 cm. For use with this method a special apparatus was produced at the All-Union Research Institute of Medical Instruments and Apparatus (S. A. Vinokurskii, V. S. Lytkina, M. F. Koryakin, L. N. Mishin), and this was employed in the present investigations.

A conditioned reflex was established in response to a bell after preliminary instructions to the subject to raise his leg to a given height as quickly as possible in response to the conditioned signal. After the formation of a well defined conditioned reflex, the conditioned stimulus was applied three times; the best result of 3 attempts was read. The following indices were recorded: 1) the latent period of the spread of excitation to the postural component; 2) the duration of preparation of the posture (the difference between the latent periods of the local and postural components); and 3) the duration of the local movement of raising the leg to a given height.

The results of the investigations were recorded in the form of the curves shown in Figs. 1 and 2. The top line records the distribution of body weight between the two supporting limbs; a rise of this curve indicates an increase in pressure on the left lower limb, a fall an increase in pressure on the right. The first fall (or rise) of the lower line indicates the time of application of the conditioned signal; the second fall (or rise) shows the beginning of the local movement of raising the leg; the rise (or fall) of the lower line denotes the end of the local movement.

EXPERIMENTAL RESULTS

In every case the establishment of the posture began by the subject pressing on the support with the limb to be raised. Only then was the body weight transferred to the opposite limb, and morover, the beginning of the local movement was always preceded by the complete transfer of the entire body weight to the opposite lower limb.

The investigations were conducted on 223 apparently healthy human subjects, with no special training in any type of sport. The results of these investigations are shown in Table 1.

TABLE 1. Indices of the Conditioned Leg-Raising Reflex in Apparently Healthy Untrained Human Subjects Depending on Age and Sex

Sex	Age (in years)	No. of subjects	Duration (in seconds) of latent period of postural component: arithmetic mean	mean square deviation	error of the mean	preparation of posture: arithmetic mean	mean square deviation	error of the mean	local reaction: arithmetic mean	mean square deviation	error of the mean
Males	16-30	42	0.108	0.022	0.003	0.273	0.073	0.011	0.103	0.027	0.004
Females		42	0.110	0.019	0.003	0.323	0.126	0.020	0.156	0.047	0.007
Males	30-45	43	0.113	0.025	0.004	0.310	0.079	0.012	0.117	0.038	0.006
Females		25	0.126	0.027	0.005	0.355	0.087	0.018	0.165	0.055	0.011
Males	45-60	29	0.146	0.046	0.009	0.355	0.104	0.020	0.133	0.042	0.008
Females		25	0.151	0.046	0.008	0.419	0.092	0.019	0.176	0.038	0.008
Males	60-75	9	0.160	0.020	0.007	0.399	0.050	0.018	0.140	0.019	0.007
Females		8	0.172	0.040	0.015	0.429	0.113	0.043	0.184	0.059	0.022

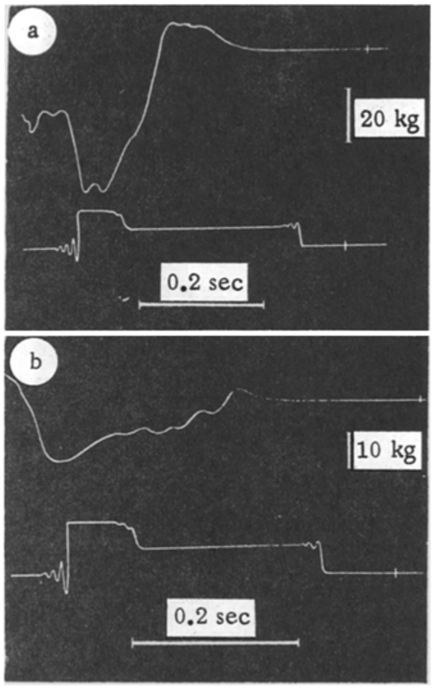

Fig. 1. Mechanograms of the conditioned reflex of raising the left leg with different degrees of transfer of the body weight from it in the initial position. a) Transfer of 33 kg, the subject weighing 80 kg; length of latent period 0.09 second, length of preparation of posture 0.19 second, length of local reaction 0.08 second; initial pressure of limb to be raised 12 kg; transfer of 10 kg by the same subject, length of latent period 0.08 second, of preparation of posture 0.13 second, and of local reaction 0.08 second; initial pressure of limb to be raised 4 kg.

It will be clear from Table 1 that in males of all groups the mean results for each index were slightly less than in the females of the corresponding groups. With increasing age, in both sexes a persistent tendency was observed for all three indices of the conditioned reflex to increase.

Animal experiments [3] have shown that the postural component of a conditioned reflex may be manifested as two main variants: a) with the initial pressure of the limb to be raised on the support; b) without the initial pressure of this limb on the support. A relationship was demonstrated between the degree of transfer of the body weight from the limb to be raised in the original position and the variant of the postural reflex. For instance, after one quarter or more of the body weight had been transferred by the animal from the limb to be raised, the postural reflex always followed the course of the first variant, but when one eighth or less of the body weight was transferred, it followed the course of the second variant. The variant with pressure is the main

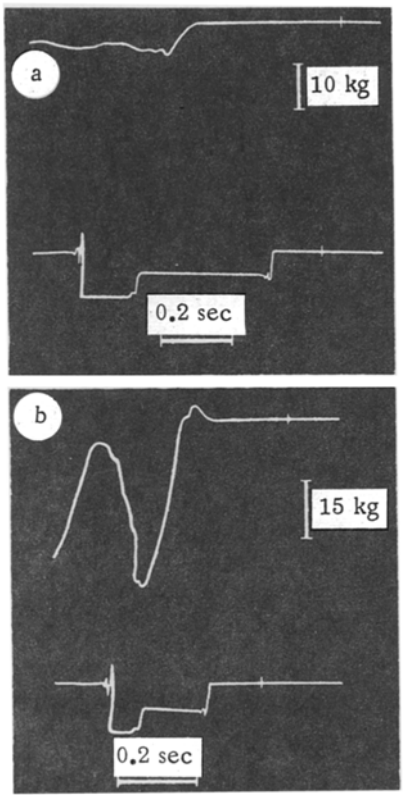

Fig. 2. Mechanograms of the conditioned reflex of raising the left leg from standing on all fours and from the ordinary standing position. a) With additional support on the hands and transferring 6 kg of the body weight from the limb to be raised by a subject weighing 78 kg in the initial position; length of latent period 0.25 second, of preparation of posture 0.11 second, and of local reaction 0.16 second. Phenomenon of pressure by the limb to be raised absent; b) in the ordinary standing position, with uniform transfer of body weight from the lower limb to be raised by an athlete weighing 68 kg in the initial position; length of latent period 0.07 second, of preparation of posture 0.11 second, and of local reaction 0.08 second; initial pressure of lower limb to be raised 4 kg.

TABLE 2. Results of Administration of Chlorpromazine (50 mg) of Subject K

Time	Duration (in seconds) of		
	latent period	preparation of posture	local movement
10 hr 20 min	0.1	0.19	0.07
12 hr 02 min	0.1	0.20	0.07
13 hr 25 min	0.1	0.33	0.07
14 hr 50 min	0.1	0.28	0.07
15 hr 54 min	0.1	0.26	0.07
16 hr 50 min	0.1	0.20	0.07

variant of the postural reflex in the animal, since its basic initial posture is one in which the body weight is nearly uniformly distributed between all four limbs. The question accordingly arises, what are the variants of the postural reflex in man?

With a uniform distribution of the body weight on both lower limbs in the initial position of the subjects, the phenomenon of pressure of the limb to be raised always occurred; the magnitude of the pressure varied from 4 to 25 kg with variations in the body weight from 40 to 110 kg. Other things being equal, with an increase in the subjects' body weight as a rule the pressure of the limb to be raised increased, and vice versa.

We increased the transfer of body weight from the lower limb to be raised, while in the initial position, successively in stages of 5 kg until five-sixths of the whole body weight had been transferred. Until three-fifths of the body weight had been transferred from this limb, the magnitude of the pressure showed little change. With a further increase in the transfer of weight, the pressure decreased progressively. Meanwhile the duration of this phenomenon was lengthened and the rise of its curve became less steep, indicating a decrease in the rate of pressure of the limb to be raised with an increase in the transfer of body weight.

Subsequently we reduced the transfer of weight from the limb to be raised in stages of 5 kg in the initial position down to a transfer of one tenth of the body weight. In this case, when the transfer of weight fell to approximately one third of the body weight, the pressure was not diminished but, as a rule, was actually increased, and the rise of the pressure curve became steeper and shorter in duration or, in other words, the rapidity of the pressure of the limb to be raised increased. With a further decrease in the transfer of weight from this limb to one tenth of the body weight, the pressure diminished, and when 5-10 kg was transferred in the initial position, the pressure sometimes reached 1-4 kg (see Fig. 1). In all these cases, however, the phenomenon of pressure of the limb to be raised invariably developed. Thus in man, the phenomenon of pressure by the limb to be raised in an elementary motor act of leg raising always develops irrespective of the degree of transfer of the body weight of the limb in the initial position of standing on two supports.

In order to confirm conclusively that this feature of the manifestation of the pressure phenomenon in man, in contrast to animals, is dependent on the human bipedal stance, we instructed the subjects to stand on all fours when

performing the conditioned reflex. If the subject transferred less than one eighth of his body weight from the lower limb to be raised in the initial position, the postural reflex could take place as in animals without pressure by the limb to be raised (see Fig. 2,a).

Animal experiments showed [3] that the magnitude of the initial pressure by the limb to be raised determines the rate of the postural reflex. It might be suggested that in man too, other things being equal, an increase in the pressure by the limb may also lead to an increase in the speed of the postural reflex. However, a careful analysis of the mechanograms when the reflexes took place rapidly showed that in most cases the increased rate of the postural reflex in man was attained not so much by an increase of pressure by the limb to be raised as by an increase in the rate of application of this pressure. This was shown on the mechanograms by an increase in the gradient of the ascending and descending branches of the pressure curve. This was revealed especially clearly when we carried out additional investigations of atheletes trained in branches of sport where speed is all important for success. As an example we reproduce the mechanogram of a tennis player E. (see Fig. 2,b). If we compare the indices of this tennis player with the corresponding indices of one of the quickest of our untrained subjects, we see that, despite the more than 60% decrease in the pressure of the limb to be raised in the former case, the rate of preparation of the posture was 70% quicker in the athlete than in the nonathlete.

As in animals, in man a decrease in the degree of transfer of the body weight from the limb to be raised leads to a shortening of the time required to prepare the posture (see Fig. 1).

Experiments on dogs [3] showed that the postural and local components of the conditioned reflex do not react in the same way to administration of chlorpromazine to the animal in a dose of up to 2 mg/kg. For instance, chlorpromazine slowed that of the posture development but left the rate of the local movement unchanged. Since numerous investigations [6, and others] have shown that chlorpromazine depresses the activity of the reticular formation of the brain stem without depressing the functions of the pyramidal system [1], we concluded that in the dog the postural component is mainly associated with the cortico-reticulo-spinal system and the local component with the pyramidal system.

In the process of evolution from the higher mammals to man, the most general functions of these particular motor divisions of the nervous system must have been preserved. In order to test this hypothesis we investigated the action of chlorpromazine on both components of the conditioned reflex in 10 apparently healthy persons. Since in man the higher regulator of both the postural and the local components is the second signal system, and since this system is itself under the influence of the reticular formation of the brain stem as regards its energy requirements, it follows that in man chlorpromazine may have, besides its direct action which it possesses in common with animals, an indirect action on both components through the second signal system. To reduce this latter effect to a minimum, we gave chlorpromazine in the first place in comparatively small doses (from 0.75 to 1 mg/kg body weight) to our subjects, and in the second place we gave it by mouth, since when given this way as opposed to parenterally, chlorpromazine produces its action more slowly and gradually.

The experiments showed that under the influence of chlorpromazine, in 6 human subjects the postural component was slowed while the local component was unchanged, and in 2 subjects the postural component was first slowed, and this was followed by slowing of the local component, in one subject both components were slowed simultaneously, and in one subject no changes were observed in the time of either component. Thus, in 8 of the 10 subjects we observed that chlorpromazine had a different action on the two components of the conditioned reflex. By way of illustration we show (Table 2) the results of administration of 50 mg chlorpromazine to subject K., weighing 60 kg (given at 10:15 A.M.).

We may conclude from these experiments that in man the manifestation of the postural component is mainly associated with the cortico-reticulo-spinal system, and that of the local component with the pyramidal system.

LITERATURE CITED

1. I. P. Baryshnikov, V. M. Vinogradov, M. N. Nikiforov, and Yu. I. Shanin, Zh. Byssh. Nerv. Deyat., 6, 6, 881 (1956).
2. V. M. Kas'yanov, Byull. Éksper. Biol., 30, 1, 16 (1950).
3. M. F. Koryakin, Investigation of the Composition of the Conditioned Motor Reflex in the Dog. Candidate dissertation [in Russian], Moscow, 1958.
4. M. F. Koryakin, Voprosy Kurort., Fizioter. i Lechebn. Fiz., 3, 256 (1958).
5. A. I. Shumilina, Collection: Problems in Higher Nervous Activity [in Russian], p. 256 (1958).
6. G. Hiebel, M. Bonvallet, and P. Dell, Sem. Hop., N. 30, p. 2346 (1954).