FORMATION OF A SKILLED MOVEMENT IN MAN EXPOSED ALTERNATELY TO OVERLOADING AND WEIGHTLESSNESS

M. A. Cherepakhin (Moscow)

UDC 612.76.014.47

Several investigations have been made of the coordination of human movements during alternate exposure to overloading and weightlessness [1-5]. No study has yet been made, however, of the formation of a skilled movement in these conditions.

An experimental investigation was conducted on a jet airplane in flights along a Kepler's parabola, at certain points of which overloading of an intensity of 2.0-2.5 units and duration of 10-12 sec, and weightlessness of a duration of 18-25 sec, developed.

EXPERIMENTAL METHOD

In each experimental flight between 4 and 8 parabolas of weightlessness were performed.

The subject was secured to a chair in the airplane by straps, in front of the experimental bench. To the bench was fixed a tensometric dynamometer, on which the subject had to press with his right index finger with a frequency of 2 per second throughout the period of change of weightiness, so that the strength of the second pressure was only half that of the first. The strength (force) of the first pressure was 5-7 kg. The muscular contractions were isometric in character.

The strength of each pressure was recorded concurrently with the accelerogram on the film of an optical oscillograph, and then subjected to mathematical analysis.

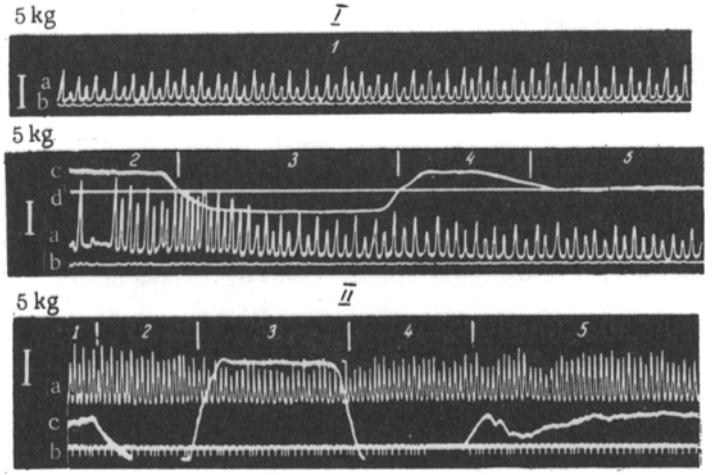

Fig. 1. Differentiation of strengths in the first flights along a parabola of weightlessness. I) Trained subject; II) untrained; a) mechanogram; b) time marker (1 sec); c) accelerogram; d) beam of unused loop. 1) Horizontal flight; 2) overloading; 3) weightlessness; 4) overloading after weightlessness; 5) horizontal flight after overloading and weightlessness. The opposite directions of deflection of the lines of the accelerogram on the mechanograms of the trained and untrained subjects is due to a change in polarity during connecting the leads from the source of power to the oscillograph.

Presented by Active Member of the Academy of Medical Sciences of the USSR V. V. Parin. Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 62, No. 7, pp. 22-26, July, 1966. Original article submitted December 19, 1964

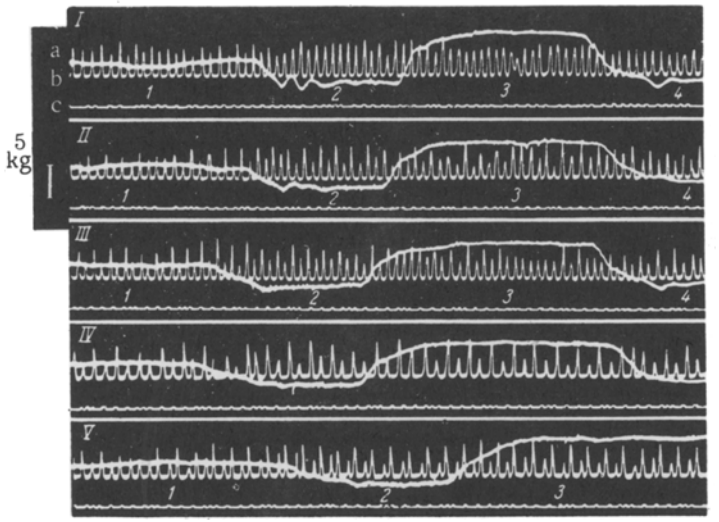

Fig. 2. Formation of a skilled movement during alternate exposure to overloading and weightlessness in the first experimental flight (subject A). I-V) Flights along a parabola of weightlessness; 1) horizontal flight; 2) overloading before weightlessness; 3) weightlessness; 4) overloading after weightlessness; a) mechanogram; b) accelerogram; c) time marker (1 sec).

The accuracy of differentiation of the strengths was estimated by the ratio between the second and the first. The optimal index of differentiation was taken to be a ratio of 0.5, when the first was twice as strong as the second pressure.

Healthy males aged from 20 to 43 years were investigated.

The subjects were divided into two groups. In Group 1 (2 subjects) the skilled movement was formed and consolidated by systematic training in the pre-experimental period on the ground. In Group 2, no such preparation was given and, consequently, all 6 subjects in this group were without special skill in differentiation. The subjects of this group had to acquire that skill during the flights along the parabolas of weightlessness.

EXPERIMENTAL RESULTS

Before the experiments began none of the subjects, apart from one of those in Group 2, had any experience of flights along a parabola of weightlessness.

The mechanograms of the strengths of the pressures in the first flights along parabolas of weightlessness of the trained and untrained subjects are given in Fig. 1. This figure shows that at all points of the flight differentiation of strengths by the untrained subject was practically absent: he pressed on the tensometric dynamometer not in accordance with the prearranged program, but with approximately equal strengths. This equality in strength was particularly marked at the beginning of the action of overloading and of weightlessness. In the trained subject the skilled movement was disturbed only in the initial period of action of overloading and weightlessness.

Examination of the mechanograms of the untrained subjects showed that at times varying from one individual to another their skills became more or less stabilized in character. Until this happened their motor reactions were extremely imperfect, for all the waves of the mechanogram were approximately equal. It was easier for the subjects to perform one stereotyped movement.

In the untrained subjects, before the skilled movement had become established, and in the trained subjects only under the influence of overloading and, in particular, of weightlessness the structure of the skill was simpler than that required by the experimental program.

In the first flights, i.e., before the corresponding skill in the untrained subjects had reached a constant and stable level, during the action of overloading and weightlessness differentiation of the strengths was exceptionally unstable and inaccurate. The occasional successful attempts may therefore be interpreted as purely accidental.

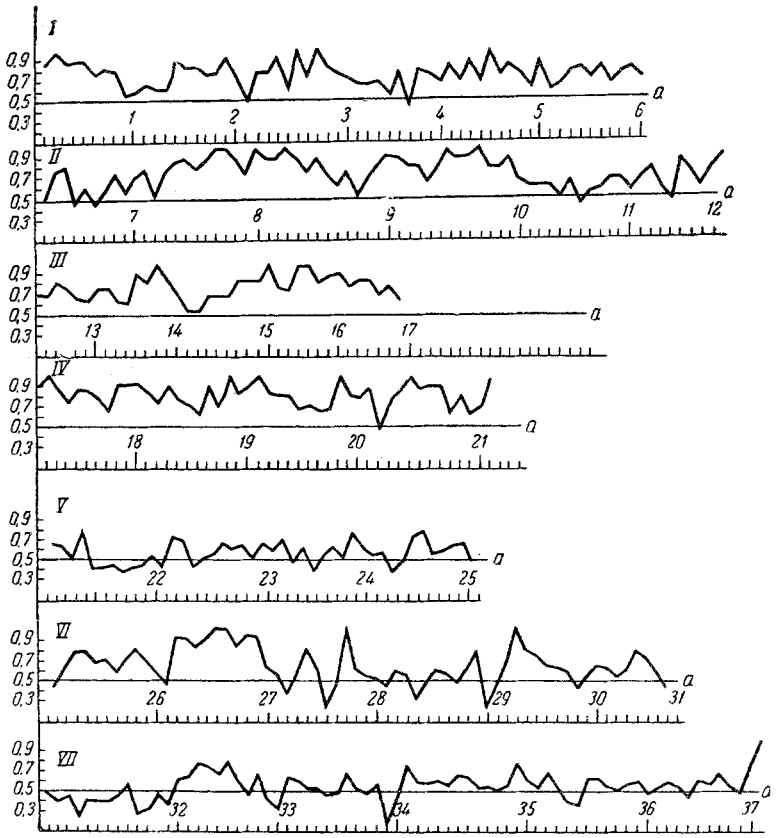

Fig. 3. Accuracy of differentiation of muscular strengths in weightlessness from the beginning and until final establishment of the skilled movement (subject P). I-VII) Experimental flights; 1-37) serial No. of flights along a parabola of weightlessness performed consecutively in experimental flights I-VII. Along the axis of ordinates – values of ratio between the second (smaller) and the first pressure. Line a) optimal accuracy of differentiation of strengths. Along the axis of abscissas – duration of weightlessness in each flight along a parabola (1 division = 2 sec).

However, with the course of time the successful attempts recurred increasingly often, as is characteristic of the formation of any skilled movement.

Figure 2 shows that the untrained subject in the first flight at the horizontal part performed his allotted task successfully enough. With the beginning of overloading and, in particular, of weightlessness the motor stereotype was disturbed. The subject pressed on the dynamometer with equal strengths and not in accordance with the program. This was regarded as a disturbance of the skilled movement of the motor perseveration type. It is also clear from Fig. 2 that in the subsequent flights along a Keplerian trajectory the degree of the perseveration was minimal. In the fifth flight the subject began to display accuracy and marked stability of the skill at quality of the skill – it marked the end of the period of formation and the beginning of the period of maintenance of the skilled movement.

The same stage of formation of the skilled movement was also observed in the subjects trained on the ground, although, admittedly, it was shorter in duration. For this reason the period of chaotic activity of the untrained subjects was regarded as a prolonged initial stage of formation of the skilled movement, before it became firmly established. It is interesting that in one of the subjects, who was untrained but had considerable experience of flights along parabolas of weightlessness, the formation of the experimental skill during the flights coincided approximately in all its characteristics with the formation of the skill in terrestrial conditions. However, this subject also revealed perseveratory movements at the beginning of exposure to weightlessness.

In most subjects the skilled movement was formed slowly in the conditions of weightlessness and overloading. At the same time, once it had been formed with great difficulty and in the course of longer periods of time, the skilled movement in these subjects became more stable and flexible than in the subjects trained on the ground. It

responded more fully to changes in the conditions in which it was performed, especially to changes in gravitation, and it seemed to preserve an imprint of the conditions in which it was created.

Skills actually used in work, sport, etc. are formed as a rule in various conditions. Moreover, all the most effective systems of training a person in some form of trade or occupation necessarily make provision for variation of the conditions in which the process of this training takes place. What is known as the flexibility of a skill, i.e., ability to act in any conditions, whether provided for in the training program or not, is achieved by ensuring that in the course of establishment of the skill, the external conditions in which it is performed are deliberately and systematically disturbed.

The process of formation of the skilled movement in time (from flight to flight) in an untrained subject is illustrated in Fig. 3. This curve may be regarded as a curve of an exercise taking place in the conditions of a rapid change from overloading to weightlessness and vice versa. To construct the graph only data for the period of weightlessness were taken, for in the conditions of weightlessness the formation of the skilled movement was attended by the greatest difficulty. Figure 3 shows that with the course of time the differentiation of the strengths during weightlessness improved steadily. In addition, at a certain moment of the 21st flight along a parabola the accuracy of this differentiation showed a qualitative change – the subject began to form his activity in accordance with the assigned experimental program. There is every reason to suppose that this moment marked a change from the stage of formation of the skill to the stage of its stabilization.

The duration of formation of the skilled movement in these experiments showed considerable individual variation. In some subjects the skill was well stabilized in the second parabola, while in others this did not take place until the 20th or 21st flight.

SUMMARY

The investigations were carried out during jet aircraft flights along Kepler's parabola. During a flight the subject under examination was to press the dynamometer with his finger so that the strength of the second pressure was half of the first one. The pressures were recorded on an oscillograph simultaneously with the accelerogram.

In one group of subjects under examination the habit developed before flights, in another it formed during flights.

The habit developed was disturbed only in the early period of overload and weightlessness. During repeated flights these disturbances became less.

The subjects in the second group acquired an experimental habit which under conditions of changed weightlessness proved more stable than in the subjects of the first group.

The formation of the habit under the alternating influence of overload and weightlessness took more time than on the earth.

LITERATURE CITED

1. L. V. Chkhaidze, In: Problems in Cosmic Biology [in Russian], Vol. 1, Moscow (1962), p. 438.
2. E. M. Yuganov, I. I. Kas'yan, N. N. Gurovskii et al., Izv. Akad. Nauk SSSR, Seriya Biol., No. 6 (1961), p. 897.
3. E. M. Yuganov, I. I. Kas'yan, M. A. Cherepakhin et al., In: Problems in Cosmic Biology [in Russian], Vol. 2, Moscow (1962), p. 206.
4. V. I. Yazdovskii, I. I. Bryanov, L. I. Kakurin et al., In: Aviation and Space Medicine [in Russian], Moscow (1963), p. 507.
5. S. J. Gerathewol, In: Problems in Medicine in Interplanetary Flights [in Russian], Moscow (1955), p. 49.