INVESTIGATION OF THE EFFECT OF VIBRATION, ALONE AND COMBINED WITH HEAT, ON THE PERIPHERAL CIRCULATION

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The effect of local vibration with a frequency of 50 Hz and amplitude of 0.7 mm was studied in experiments on healthy human volunteers. Using Burch's modification of the method of occlusion plethysmography, together with capillaroscopy, the study showed that vibration reduces the volume and velocity of the inflow and outflow of blood, reduces the number of functioning capillaries, and causes clouding of the capillaroscopic background. Application of heat during vibration (warming the surface of contact to a temperature of 40-43°C) abolishes or diminishes the vasoconstrictor action of vibration.

An important role in the pathogenesis of vibration disease is played by disturbance of the peripheral circulation [1, 4, 7]. These distrubances are based on the vasoconstrictor response of small vessels to vibration [2, 10].

At the same time, the opposite action of local heat is also well known [5, 8]. However, so far as the writers are aware, there are no experimental data in the literature for responses of the peripheral vascular

TABLE 1. Indices of Circulation in Finger Tip of Exposed Hand During Action of Vibration Alone and Combined with Heat

Time of test	Volume (in $mm^3/5\ cm^3$			Velocity in $mm^3/5\ cm^3/sec$				
	of pulse wave	of inflow at end of pulse wave I	of outflow 0.1 sec before end of pulse I	inflow	inflow in stage of diastole	a (in sec)	$\frac{a}{a+b}$	Number of functioning capillaries per field of vision
Series I								
Before exposure (control I)	10,6	19,8	16,5	28,4	38,6	0,22	0,19	17
After exposure (1 h)	6,7	11,4	9,7	15,1	22,9	0,32	0,23	14
P	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
Series II								
Before exposure (control 2)	10,3	19,6	16,9	24,2	37,4	0,23	0,19	16
After exposure (1 h)	9,4	19,0	16,2	23,6	35,1	0,25	0,2	17
P	<0,05	>0,2	>0,1	>0,1	0,1>P>0,05	>0,1	>0,2	0,1>P>0,05

Legend: a) time of rise of pulse wave; b) time of fall of pulse wave.

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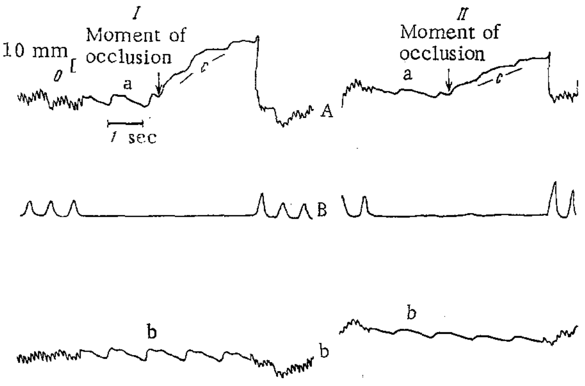

Fig. 1

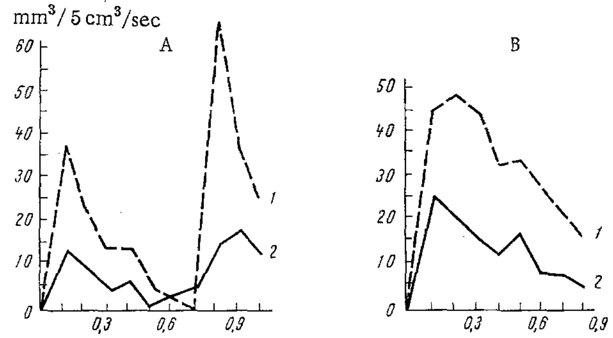

Fig. 2

Fig. 1. Changes in plethysmogram as the result of exposure to vibration; I) Before vibration; II) after vibration. A) Curve from finger with occlusion cuff; B) curve of respiration; C) curve from finger without occlusion cuff.

Fig. 2. Changes in velocity of inflow and outflow of blood (in $mm^3/5\ cm^3/sec$) as a result of exposure to vibration (data of one experiment). A) Velocity of inflow; B) velocity of outflow. 1) Before vibration; 2) after vibration.

system to simultaneous application of these two stimuli with their opposing effects. If these effects canceled each other out, this would be good grounds for using heat stimulation as a prophylactic measure against the development of vibration disease in persons working with vibrating tools.

To investigate this problem special experiments were carried out on a group of volunteers consisting of 10 young (23-35 years) healthy men, not previously working with vibrating tools.

EXPERIMENTAL METHOD

The state of the peripheral circulation of all subjects was studied at the same time by Burch's modification of the method of occlusion plethysmography [12] and by capillaroscopy under the influence of vibration (series I) and vibration accompanied by heat (series II). The subject's hand lay freely on the vibrating surface of a bench producing sinusoidal oscillations with a frequency of 50 Hz and amplitude of 0.7 mm. The duration of stimulation was 1 h. Heat stimulation was applied by warming the vibrating area by means of an insulated electric heating element to 40-43°C.

EXPERIMENTAL RESULTS AND DISCUSSION

In each series about 40 experiments using capillaroscopy and about 15 experiments using Burch's modification of occlusion plethysmography were performed.

Good agreement was observed between the initial data on different days in the same subjects (controls 1 and 2, Table 1). In the experiments of series I (vibration), definite and substantial changes in the blood supply were observed, as shown by the volume of the pulse wave, and the volume and velocity of inflow and outflow of blood. Examination of Fig. 1 shows that the volume of the pulse wave after vibration (II, A, a) was much less than initially (I, A, a). The same result was observed by comparing the plethysmograms without occlusion (II, C, b and I, C, b). In addition, the course of the curve after occlusion under the influence of vibration was flatter than initially (II, A, c and I, A, c).

Changes in the blood flow following exposure to vibration are shown in Fig. 2.

The results of experiments of series II (Table 1) show that heat stimulation if acting together with vibration almost completely prevented the vasoconstrictor effect of the vibration. Both the number of functioning capillaries and the volume and velocity of the blood flow through them at each contraction of the heart reached almost the same level as in the original state before the start of stimulation. Whereas under the influence of vibration the apex of the pulse wave was shifted to the right – its maximum in the control occurred at a mean value of 0.22 sec, compared with 0.32 sec in series I, in series II no changes in elasticity of the vessel wall were observed. The velocities of inflow and outflow in these subjects, calculated from the results of the experiments, were very close to those obtained by Burch [12] in healthy young men under comfortable conditions: inflow 21.9-28.6 $mm^3/5\ cm^3/sec$, and outflow 29.1-37.1 $mm^3/5\ cm^3/sec$ (in the stage of diastole). The action of vibration had a marked effect which could be attributed to the result of an increase in tone of the peripheral vessels, both arteries and veins. Local cooling has the same effect in principle. Many investigators [9] have found that the more strongly contracted the blood vessels, the more sensitive they are to vasoconstrictor effects. It thus follows that a disturbance of blood supply produced by vibration when the room temperature is comfortable could be still greater if the vibration had acted during local cooling of the hands. This is confirmed by the observations of Andreeva-Galanina et al. [1] and of Bragina [3] and Malinskaya [6], who found that spasm of the blood vessels develops soonest and strongest during both general and local cooling of the workers' limbs.

The results of these tests show that thermal dilatation can be used effectively to counteract the constrictor effect of vibration. This conclusion, it must be emphasized, is valid only for the effect of local vibration on tone of the peripheral vessels, and it must not be extended to other "points of application" of the effect of vibration. For example, changes in permeability as a result of disturbance of the functional capacity of the endothelial cells of the capillary wall, as demonstrated by clouding of the capillaroscopic background, are not prevented by the action of heat.

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