

Cardiovascular responses to head-stand posture

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RAO, SHANKER. *Cardiovascular responses to head-stand posture.* J. Appl. Physiol. 18(5): 987-990. 1963.—Reports of cardiovascular responses to head-stand posture are lacking in literature. The results of the various responses, respectively, to the supine, erect, and head-stand posture, are as follows: heart rate/min 67, 84, and 69; brachial arterial pressure mm Hg 92, 90, and 108; posterior tibial arterial pressure mm Hg 98, 196, and 10; finger blood flow ml/100 ml min 4.5, 4.4, and 5.2; toe blood flow ml/100 ml min 7.1, 8.1, and 3.4; forehead skin temperature C 34.4, 34.0 and 34.3; dorsum foot skin temperature C 28.6, 28.2, and 28.2. It is inferred that the high-pressure-capacity vessels between the heart level and posterior tibial artery have little nervous control. The high-pressure baroreceptors take active part in postural adjustments of circulation. The blood pressure equating mechanism is not as efficient when vital tissues are pooled with blood as when blood supply to them is reduced.

man heart rate blood flow skin temperature

THE PURPOSE OF THIS STUDY was to find the effect on some common cardiovascular responses in man of standing erect and head-stand posture in relation to the horizontally supine position of the body. Numerous observations on responses to tilting of the body from supine to upright position and L posture are available (1-4), but studies of responses to a full-scale vertical head-down position are lacking.

The various responses studied were the changes in heart rate, arterial blood pressure in the brachial and the posterior tibial arteries, and the blood flow through the finger and toe. Attempts at determining indirectly the blood flow through the forelimbs using the occlusion plethysmographic technique were unsuccessful, as it was difficult to maintain the limbs steady during head-stand posture, and to prevent mechanical displacement within the plethysmograph jacket.

METHODS

The subjects of this study were healthy, male, medical students between 19 and 23 years of age with a mean weight of 55 kg and a mean height of 168 cm. The

experiments were carried on about 4-5 hours after a light breakfast and after a 30-min rest in the laboratory. The head-stand posture adopted by the volunteers was reported earlier (5).

The heart rate was counted with the aid of a stethoscope over a period of 1 min. Arterial blood pressure was recorded by the auscultatory method, the pressure cuffs having been fixed on the left arm and just above the ankle joint. An oscillatory method¹ was used to check the results obtained by auscultation. This was found to be very useful on a few occasions when difficulty was experienced in hearing the Korotkov's sounds over the posterior tibial artery. A small diaphragmed chest piece was used for auscultation in this region.

Blood flow through the digits was determined indirectly using a finger plethysmograph² and recording the volume changes electromagnetically. The apparatus and method of recording the volume change was very similar to the one used by Hyman et al. in their work on distensibility of digital blood vessels (6). Care in calibrating and eliminating the bias created by mechanical artifacts was taken.

Additional information about the blood flow through the superficial tissues was obtained by recording the skin temperature at two points: center of forehead, and dorsum of foot at the base of the second toe. Temperature was recorded thermoelectrically; the iron-constantan thermocouples were fixed in contact with the skin with sticking plaster.

Only one response was measured at each sitting. The sequence of recording was: lying horizontally supine, standing erect, head-standing, and finally, again, the horizontal posture. The two horizontal positions thus served as controls and reference levels for the other two postures. All the readings were taken after a period of at least 5 min had elapsed after assuming a particular posture. This period was thought to be sufficient for circulatory and metabolic adjustments and to develop a steady state in the subject. Brachial blood pressure and finger blood flow were recorded at heart level in all the three postures. The elbow and arm were supported, whenever necessary, and steadied. The temperature of

¹ Pochon's oscillometer, G. Boullite, 15a 21, Rue Bobillot, Paris, France.

² Cardiopan equipment, Fred Liechti Ag, Berne, Switzerland.

the room ranged between 25 and 29 C, but varied only to the extent of 0.5 C during the course of an experiment. The head-stand posture and the arrangement of apparatus is shown in Fig. 1.

RESULTS

When a recumbent human is tilted to an upright position, it is estimated that about 400 ml of blood leaves the thoracic compartment to accumulate in the lower portion of the body due to the gravity effect (7). This functional hemorrhage lowers the arterial and carotid sinus pressure and increases the heart rate by about 20 beats/min. At the same time the posterior tibial arterial pressure increases to the extent of the hydrostatic pressure exerted by the column of blood equal in height to the vertical distance between the posterior tibial artery and the heart level. This pressure is equal to about 85 mm Hg.

In the present series of six healthy young students, the heart rate in the erect posture increased by 17 beats/min and the mean pressure in the posterior tibial artery by 98 mm Hg. The average distance between a point 5 cm above the medial malleolus (the point of compression

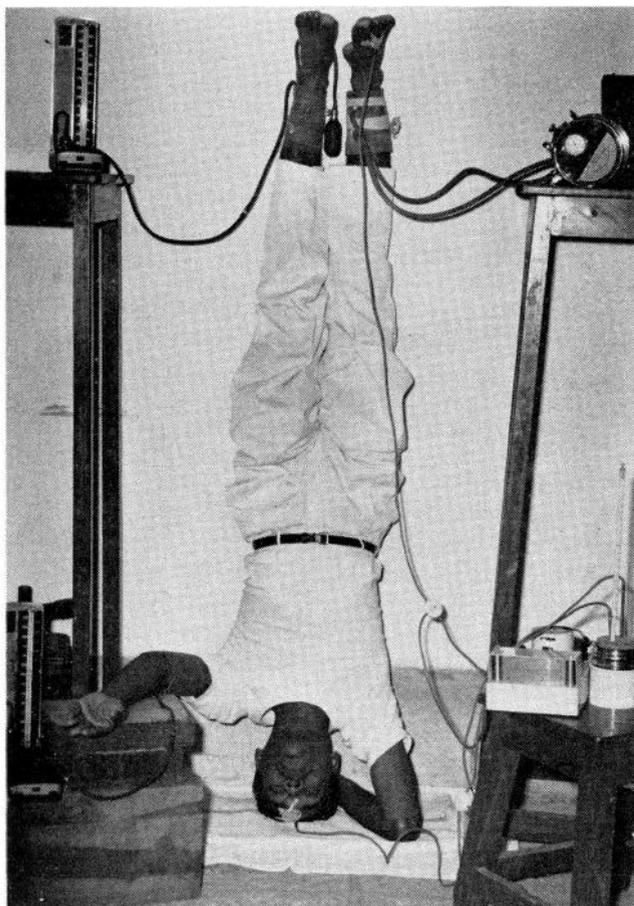


FIG. 1. A subject in head-stand posture and the arrangement of apparatus.

TABLE 1. *Various cardiovascular responses in three postures**

Responses	Horizontal Supine	Standing Erect	Head Standing	Horizontal Supine
Heart rate/min	67	84	69	63
Mean art. pr. brachial mm Hg	92.5	89.5	107.5	89.5
Syst. pr. brachial mm Hg	112	104	125	109
Diastolic pr. brachial mm Hg	73	75	90	70
Pulse pr. brachial mm Hg	39	29	35	39
Mean art. pr. posttibial mm Hg	97.5	195.5	9.5(?)	98
Syst. pr. posttibial mm Hg	120	213	19	117
Diast. pr. posttibial mm Hg	75	178	0	79
Pulse pr. posttibial mm Hg	45	85	19(?)	38
Toe blood flow ml/min 100 ml	7.1	8.1	3.4	5.7
Finger blood flow ml/min 100 ml	4.5	4.4	5.2	4.7
Skin temp. forehead C	34.40	34.03	34.70	34.32
Skin temp. dorsum foot C	28.62	28.23	28.23	27.78

* Each value is an avg. of 6 observations, 1/subj.

with the sphygmomanometer cuff), and the sternal angle (heart level) was 120.5 cm. A slight fall in the mean brachial arterial pressure was also invariably noted.

A change from the erect to the head-stand posture had the reverse effect. The heart rate was now reduced by 15 beats/min. The mean brachial arterial pressure rose by 15 mm Hg, the posterior tibial systolic pressure fell steeply to 19 mm Hg, while the posterior tibial diastolic pressure in all the subjects subsided to below zero and could not be recorded.

Digital blood flow also showed a tendency to alter with the various postures. The temperature of the forehead skin varied directly with the brachial arterial pressure, whereas the response from the skin of the dorsum of the foot was inconsistent.

The mean results of the various observations on six subjects are given in Table 1 and graphically represented in Fig. 2.

DISCUSSION

The results show that in the head-stand posture the heart beats 69 times/min. This rate is higher than it was when recumbent. The gravity effect, it was expected, would reduce the rate far below the recumbent level as opposed to the increase of 17 beats/min when erect. The comparatively higher heart rate in the head-stand posture may be partially due to a 48% increase in the general metabolism (5). However, there must also be other causes for this increase.

The mean pressure in the brachial artery falls only by 3 mm Hg in the erect posture but is raised appreciably by 15 mm Hg while standing on the head. The systolic pressure also shows a similar trend in the two postures.

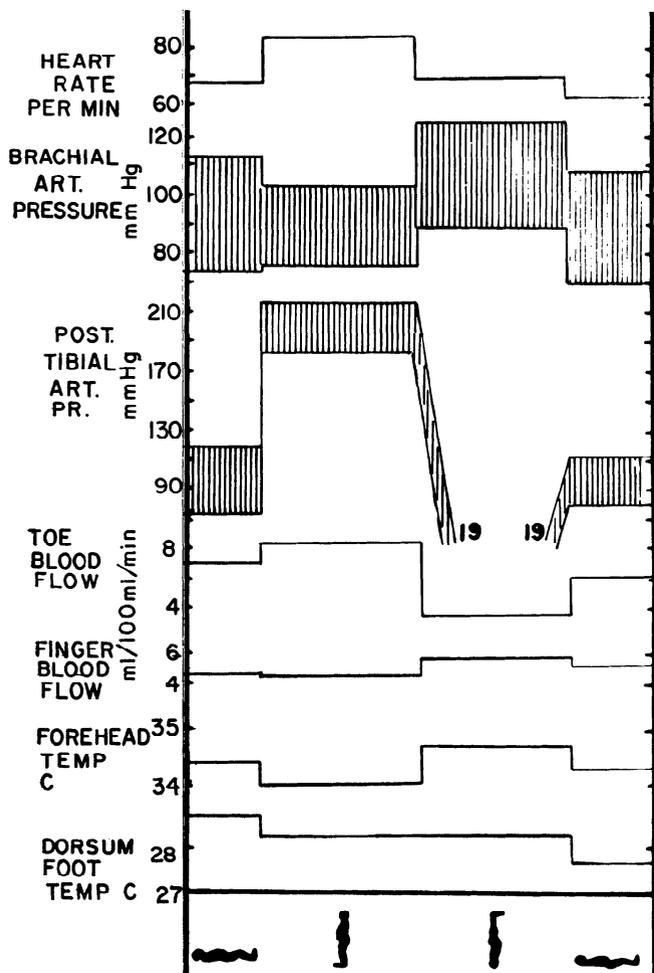


FIG. 2. Effect of 3 postures on various cardiovascular parameters. Responses do not strictly follow the time course.

Currens (8) observed no appreciable change in the brachial systolic pressure after assuming the erect position in 73.5% of his 1,000 cases. The comparatively large rise of brachial systolic and mean arterial pressure in the head-stand posture would mean that a larger quantity of blood than 400 ml accumulates in the dependent parts of the body in this posture, and/or that the blood pressure equating mechanism is not very efficient in dealing with a larger volume of circulating blood around the vital tissues as when it is exposed to a smaller volume, as while standing erect.

The systolic pressure in the posterior tibial artery rises by 93 mm Hg after standing and falls nearly equally in the head-stand posture. This corresponds to the shift in the hydrostatic pressure exerted by a calculated column of blood of 121 cm. The observed height of this column (distance between the point of compression of the posterior tibial artery and heart level) was 120.5 cm. This agrees well with the findings of Flack and Hill (9) in a set of similar experiments. It may be inferred from these observations that large changes of blood pressure in the posterior tibial artery do not activate blood pressure regulating reflexes, as do pressure changes in the carotid

sinuses. Thus, it provides additional evidence in favor of the statement that there is little nervous control of the capacity system in human limbs (3).

The reaction of digital blood flow to the various postures is varied and complex. A summary of the numerous conflicting opinions and laboratory findings reported in literature on the subject is given by Abramson et al. (10). In the present investigation, a slight change in local circulation due to alteration of limb position was noted. The finger blood flow, recorded at the heart level, was reduced very slightly in the erect position and was increased to some extent while standing on the head. The reverse was the case of the blood flowing through the toe. In view of the small number of observations in the present series and in the face of the severe criticism against the venous occlusion plethysmographic technique of digital blood flow estimation it is doubtful if any significance should be attached to the results quoted above.

The forehead skin has no vasoconstrictor nerve supply in contrast with the skin of the foot, which is supplied with only vasoconstrictor fibers. Hence, the temperature of the skin at these two points was recorded in an attempt to verify the belief that only the vasoconstrictor fibers are primarily concerned in the postural adjustments of circulation (7).

The results of the present investigation show that the forehead skin temperature decreases uniformly by about 0.4 C in the erect and increases by 0.7 C in the head-stand postures. It also reveals a direct correlation with the brachial arterial pressure, as shown graphically in Fig. 3. This may point to an active participation of the high-pressure baroreceptor-vasodilator mechanism in postural adjustments of circulation and may be argued thus.

The temperature of the skin in any part is determined by the rate of blood flowing through it. In the region of the forehead the blood flow is mainly controlled by vasodilator fibers. As such, the superficial temperature of this part may be taken as an index of the activity of the vasodilator mechanism. The carotid and aortic baroreceptors are known to exert a vasodilator effect when stretched. Such a stretch response is evident in the

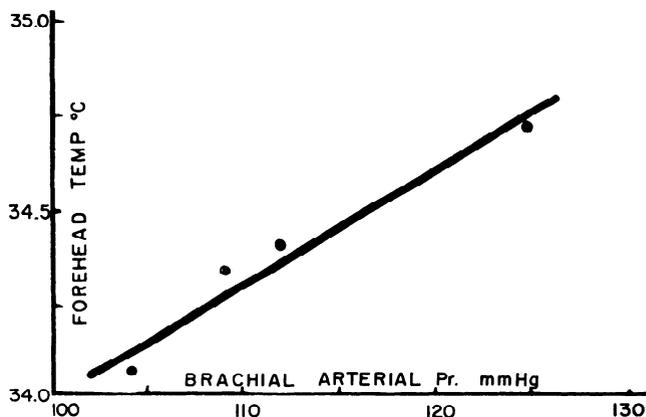


FIG. 3. Relation between means of brachial systolic pressure and forehead skin temperature.

present set of experiments where over 400 ml of blood is shifted from one to the other side with change of posture. The carotid and aortic pressures were not directly recorded in the present series of experiments, yet the brachial artery, being a capacity vessel of a limb and having little nervous control, can be taken to indirectly reflect these pressures and hence a relation between the brachial pressure and forehead skin temperature can be established.

The skin temperature on the dorsum of the foot is the same in erect and standing-on-head positions. This we expect to be appreciably reduced in the latter condition, as very little blood flows in the foot while standing on the head. However, the discrepancy may be due to the short duration of the posture and to recording results before the temperature had reached a steady state.

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