EFFECT OF LOCAL TEMPERATURE CHANGES ON GAS EXCHANGE IN MAN

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Changes in the gas exchange were investigated in healthy human subjects before and after local cold and hot baths. Regular changes in gas exchange were found, and they differed with the time of year. To elucidate the physiological mechanisms of this response, repeated tests were conducted on the same person (patients with thermoanesthesias, and healthy subjects under sedation). The results obtained indicate a conditioned-reflex nature of extinction of changes in gas exchange during repeated application of local temperature stimuli.

The local action of cold or heat can evoke a generalized thermoregulatory response in the same duration as that to general cooling or heating. However, studies of this phenomenon have dealt mainly with physical thermoregulation. Changes in gas exchange during local temperature stimulation have formed the subject of only isolated investigations.

The writer has studied the effect of local temperature changes on the intensity of gas exchange in healthy subjects.

EXPERIMENTAL METHOD

Experiments were carried out on 101 subjects (33 women aged from 18 to 52 years and 68 men aged from 17 to 58 years). Under ordinary conditions of testing basal metabolism, using a Soviet "Spirograph" apparatus, the oxygen consumption was recorded for 5 min. Next, after a short rest, one hand and the lower third of the forearm were immersed in cold (0°) or hot (45°) water. The oxygen consumption was again recorded for 5 min after exposure to the temperature stimulus for 5 min continuously.

Tests were carried out at different times of year: from the middle of November to the middle of April and from the beginning of June to the middle of September.

RESULTS

The results are given in Table 1. They show that in winter the cold procedure as a rule increased the gas exchange, while exposure to heat reduced it. In 44 subjects tested by the application of local cooling, the gas exchange increased on the average by 9.7 ± 0.9% (changes in gas exchange of up to 2% in all tests were assessed as "no change"). Only in one case was a decrease of 8% in the gas exchange observed. Application of heat in winter, conversely, reduced the gas exchange on the average by 6.3 ± 0.9%. Only in two subjects was the gas exchange increased by 8.9 and 3.6%, respectively.

During summer opposite changes in gas exchange took place during exposure to local temperature stimulation. For example, during the cold test an increase of gas exchange was observed in none of the 21 subjects. In three subjects the gas exchange was unchanged, and in 18 it was reduced on the average by 7.1 ± 0.9%. The heat test in summer as a rule caused an increase in gas exchange (on the average by 11.7 ± 1.8%). Only in one case was the gas exchange reduced by 9.5%.

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TABLE 1. Changes in Gas Exchange in Subjects Exposed to Local Temperature Stimulation, Depending on Season

Change in gas exchange	Winter period		Summer period	
	cold	heat	cold	heat
Increased	37	2	0	19
Lowered	1	33	18	1
No change	6	12	3	6
Total	44	47	21	26

From the middle of April until the end of May and from the beginning of September until the beginning of November, the changes in gas exchange did not exhibit that definite direction which was observed in winter and summer. In the spring and fall 23 subjects were tested, and some of them responded to temperature stimulation by changes in gas exchange of the "summer" type, others by changes of the "winter" type. This was evidently associated with seasonal readjustment of the reactivity of gas exchange.

Seasonal changes in reactivity of the gas exchange under the influence of local temperature stimulation must be assumed to be part of the seasonal readjustment of thermoregulation as a whole.

To elucidate the mechanism of these responses of the gas exchange, a number of patients with syringomyelia, aged from 16 to 55 years, were tested. In all these patients, besides other manifestations of syringomyelia, complete thermoanesthesia of the forearm and hand was present on one or both sides. Local exposure of the hand and forearm, in which temperature sensation was completely absent, to cold and heat evoked the same changes in gas exchange as in healthy subjects. The appearance of several thermoregulatory responses (shivering, polypnea, changes in the skin vessels) during heating and cooling of denervated parts of the body has been described in the literature. Possible explanations of these facts have been fully examined by Veselkin [1].

During the repeated action of the same temperature stimuli with intervals of a few days, the changes in gas exchange disappeared.

In 11 subjects tested repeatedly by cold in the winter period, for example, the gas exchange was increased on the average by 13.8% during the first test. During the second cold test, no changes in gas exchange occurred in five subjects, while in the remaining six persons the mean increase was 8.8%. During the third test nine subjects gave no response. In the remaining two subjects, extinction of the response was observed only after the fifth test.

Gas exchange of 13 subjects was recorded during local temperature stimulation over a period of 30-40 min with intervals of 2 min every 5 min. These tests showed that the change in gas exchange obtained during the first period of temperature stimulation diminished as the test continued, and by 20-25 min the gas exchange had returned to its original level.

To elucidate the mechanisms of extinction of these responses, the following investigation was carried out on eight subjects after complete extinction of the responses of gas exchange had been obtained. In the morning, before breakfast, chloral hydrate was given by mouth in a dose of 1-1.5 g. After well-marked and steady sleep inhibition had arisen, the oxygen consumption was recorded for a period of 5 min. Then, after a short rest, the hand and lower third of the forearm were immersed in cold or hot water. After 5 min of continuous exposure to the temperature stimulus, the oxygen consumption was then recorded for the next 5 min. The use of chloral hydrate on all eight subjects with extinction of the gas exchange response showed that local temperature stimulation during sleep inhibition again evokes a definite response of the gas exchange in the previous direction. This is evidence of the conditioned-reflex nature of the extinction.

LITERATURE CITED

1. P. N. Veselkin, Fever [in Russian], Moscow (1963).