RESPIRATION THROUGH THE SKIN IN PERSONS OF VARIOUS AGES (from 3-100 years)

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In previous research work carried out on persons 20-30 years of age we showed [1] that cutaneous respiration in man at rest and under ordinary atmospheric conditions amounted to 1-1.5% of the pulmonary respiration, but that there was a steep rise (to 8% or more) under unfavorable conditions (high temperature, heavy physical work, asphyxiation, hypoxia) and in a number of pathological states in which a rise compensated to a certain degree for a deficient pulmonary gas exchange.

In the present work we studied the age peculiarities in respiration through various areas of the human skin.

METHODS

The investigations were carried out on persons aged from 3-100 years by a method which we developed during earlier work [1]. At the same time as we made measurements on the cutaneous respiration we determined the pulmonary gas exchange by the Douglas—Haldane method.

Those employed in the tests were healthy persons who had rested for an hour lying on a couch. Ninety-three persons in all were examined and they belonged to the following age groups: 3-4, 6-7, 9-10, 13-14, 21-30, 31-40, 41-50, 61-80, and 81-100 years. The results of the investigations were statistically examined by an analysis of variance.

RESULTS

As is seen from Table 1, among children 3-4 years old, there were almost no differences in the respiration through the various areas of skin, the fluctuations over the different areas being within the limits of 75-78 ml/h/m^2 of body surface, both for the absorption of oxygen and for the excretion of carbon dioxide.

Topographical differences in cutaneous respiration were noticed among the age groups. Thus, in children 6-7 years old, the gas exchange through the thorax and abdomen was already rather higher than that through the skin in the thigh region. In children 9-10 years old, the highest rate of exchange was observed through the skin of the thorax, a somewhat lower rate through the abdominal skin and a still lower rate over the thigh region.

Besides that, the intensity of gas exchange through the different areas of skin increased with age. Thus, if the oxygen absorption through the thoracic skin of a 3-4 year old child was, on an average, 78 ml/hour, then the average absorption increased to 99 ml/hour in a child of 6-7 years, to 106 ml/hour at 13-14 years and at an age of 21-30 years it rose to 108 ml/hour. In persons 31-40 years old, oxygen absorption through the skin rose still further and amounted to 171 ml/hour. The same high rate of gas exchange through the thoracic skin, as through the skin in other areas, was observed in persons 41-50 years old.

On the other hand, in individuals over 50 years old the intensity of respiration through the various areas of skin diminished. A gradual reduction in the amount of oxygen taken up by the skin was observed in persons 80 years old. Between 80 and 100 years, the intensity of oxygen consumption remained at the previous level or was a little higher.

TABLE 1. Respiration through Individual Areas of Skin in Persons of Various Ages (average data)

Age (in years)	No. of persons examined	Respiration through individual areas of skin (in ml/hour/m²)							
		Thorax		Abdomen		Thigh			
		Excretion of CO_2	Absorption of O_2	Excretion of CO_2	Absorption of O_2	Excretion of CO_2	Absorption of O_2		
3—4	8	78,2±4,1	78,1±4,0	77,3±4,3	78,7±4,2	75,8±4,0	76,8±3,8		
6—7	8	99,5±3,8	99,8±3,9	99,4±3,9	99,1±3,9	77,1±2,7	78,4±2,9		
9—10	7	103,2±3,7	103,2±3,9	101,0±3,8	101,7±3,9	93,2±3,8	94,9±4,0		
13—14	7	107,0±4,9	106,4±5,0	104,6±5,2	105,8±5,1	94,6±4,2	94,5±4,2		
21—30	16	108,3±2,4	108,3±2,6	129,2±2,6	128,1±2,4	100,4±2,5	98,5±2,5		
31—40	15	171,3±14,3	171,5±14,4	131,5±7,6	132,9±7,7	110,4±7,3	106,8±7,3		
41—50	8	171,2±15,5	173,2±16,3	150,4±13,1	147,7±13,2	130,2±10,8	130,5±10,9		
61—80	11	120,9±6,2	124,6±6,3	114,9±10,9	116,4±10,9	102,1±7,7	101,9±7,7		
81—100	13	134,5±7,8	134,0±7,8	113,1±8,8	115,5±8,9	113,5±7,4	108,0±7,4		

Similar changes with age occurred in the excretion of carbon dioxide through the skin.

A simultaneous study of the pulmonary gas exchange in these same individuals showed that both the uptake of oxygen and the excretion of carbon dioxide, calculated on 1 m^2 of body surface, gradually decreased with age.

As is seen from Figs. 1 and 2, the changes in respiration through the skin and through the lungs which take place with aging, are both different (Fig. 1 is drawn from the data in Table 1). Respiration through the skin increases at first but later, beginning at the age of about 50 years, slowly diminishes, whereas respiration through the lungs, calculated on unit surface of the body, gradually diminishes from the age of 3 to 70-80 years. Afterwards, the intensity of pulmonary respiration remains at the previous level or even rises a little.

A comparison which we made between the magnitudes of respiratory exchange through unit surface of skin and the respiration through unit surface of the lungs showed that, in comparison with the lungs, the cutaneous gas exchange increased with age (Table 2). If in the 3-4 year old child the respiration through the various areas of skin which we measured was 0.70-0.73% of the pulmonary gas exchange, then between the ages of 61-80 years it had reached 1.5-1.8%.

As our investigations showed, the changes in the oxygen consumption through the skin and in the amount of carbon dioxide excreted were almost equal and, consequently, the relationship $\frac{CO_2}{O_2}$ in all age groups was, as a rule, close to or equal to unity. At the same time, the respiratory quotient of the pulmonary gas exchange in individuals fluctuated from 0.7 to 1.0. This implies that it is impossible to judge the changes in the metabolism of the organism from a consideration of the respiratory quotient of the cutaneous respiration: the respiratory quotient for pulmonary respiration

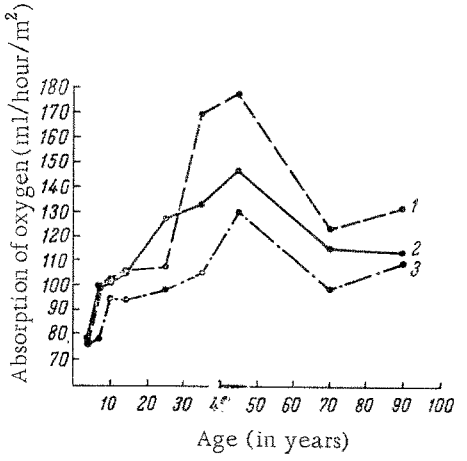

Fig. 1. Age peculiarities in the respiration through individual areas of skin in man (average data). 1) Throrax; 2) abdomen; 3) thigh.

TABLE 2. Comparative Data on Cutaneous and Pulmonary Respiration in Persons of Various Ages

Age (in years)	No. of persons examined	Cutaneous respiration compared with pulmonary gas exchange (in % estimated on 1 m^2 of skin and lung surface)					
		Thorax		Abdomen		Thigh	
		Carbon dioxide excretion	Oxygen absorption	Carbon dioxide excretion	Oxygen absorption	Carbon dioxide excretion	Oxygen absorption
3-4	8	0.73	0.73	0.72	0.73	0.70	0.71
6-7	8	0.85	0.86	0.85	0.84	0.66	0.67
9-10	7	1.02	1.02	1.00	1.01	0.92	0.94
13-14	7	0.97	0.97	0.95	0.96	0.86	0.86
21-30	16	1.21	1.21	1.44	1.42	1.11	1.09
31-40	15	1.69	1.69	1.29	1.30	1.09	1.05
41-50	8	1.76	1.78	1.55	1.52	1.34	1.34
61-80	11	1.81	1.87	1.72	1.75	1.53	1.53
81-100	13	1.73	1.73	1.46	1.49	1.46	1.39

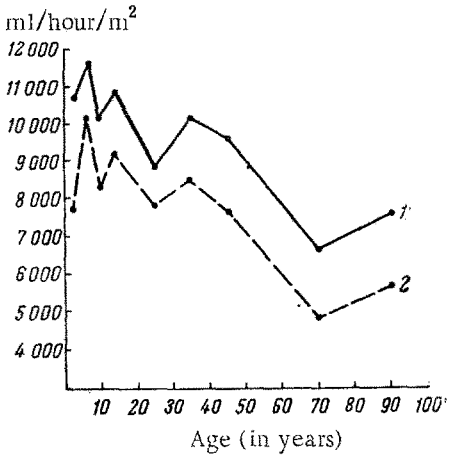

Fig. 2. Age peculiarities in the respiration through the lungs in man (average data). 1) Oxygen absorption; 2) carbon dioxide excretion.

should be used for that purpose. The relationship $\frac{CO_2}{O_2}$ for cutaneous respiration has quite another meaning; its magnitude is characteristic of the relative intensity of the processes of carbon dioxide excretion and of oxygen absorption through the skin.

The data derived from the tests show that the magnitude and character of the distribution of cutaneous respiration over various parts of the body change with age. A gradual drop in oxygen absorption by the lungs and skin in individuals of advancing age may be attributed evidently, to a deceleration in metabolism, a decrease in oxidation processes at cell level and, lastly, to a reduction in the utilization of oxygen by the tissues. Hence, it follows that the state of cutaneous respiration is closely linked with the formation, development and decline of the thermoregulatory mechanism of the body.

SUMMARY

Respiration through various areas of the skin (chest, abdomen and thigh) was studied in persons, aged from 3-100 years.

In children the skin respiration showed some difference from that in adults. Respiration through various areas of the skin is of equal intensity in children, aged from 3-4 years. With advance in age there appear topographical peculiarities of skin respiration which are retained throughout life. Gradually there is a rise of the oxygen consumption by various areas of the skin, as well as in the amount of carbon dioxide given up. The respiration intensity through the skin rises up to the age of 50, and then declines to the age of 80, remaining almost unchanged after this age. At the same time, the pulmonary gaseous exchange shows a gradual reduction with increasing age (estimated on unit area of body surface).

A gradual reduction of the pulmonary and skin oxygen consumption in senile individuals may be evidently attributed to decelerated oxidation, to diminished oxidation processes at the cell level and finally to reduction of the oxygen utilization by tissues.

The magnitude and character of respiration distribution over various areas of the skin are closely associated with the formation, development and functional inhibition of the human thermoregulatory mechanism.

LITERATURE CITED

1. N. M. Petrun', Gas Exchange through the Skin and its Significance for the Human Organism [in Russian] Moscow (1960).