STATE OF GAS EXCHANGE IN RECUMBENT AND ORTHOSTATIC POSITIONS AND UNDER PHYSICAL LOAD IN HEALTHY PERSONS OF VARYING AGE, SEX AND BODY BUILD

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16. Abstract Age effect on gas exchange was studied in the recumbent and orthostatic positions and under physical load in 37 healthy normal males aged 17-72 and 20 females aged 15-49, although only the statistics for males were admitted in the result calculations. The indices studied were oxygen consumption, oxygen pulse, oxygen requirement, recovery coefficient, oxygen consumption for 1 kg exerted load and work efficiency. Blood ratio of lactate/pyruvate was also determined. The elderly male group (50-72) showed these findings for normal persons: less oxygen consumed in rest and moderate exercise; increased oxygen used (common to all groups) when vertical position assumed more markedly than in younger persons; less oxygen consumed, lower oxygen pulse, recovery coefficient and work efficiency under moderate physical load; the over 50 require a large amount of oxygen and show a sharp rise in lactic acid and blood lactate/pyruvate ratio. Men and women of the same age and degree of physical development showed no difference in oxygen consumption during rest and physical load.

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STATE OF GAS EXCHANGE IN RECUMBENT AND ORTHOSTATIC POSITIONS AND UNDER PHYSICAL LOAD IN HEALTHY PERSONS OF VARYING AGE, SEX AND BODY BUILD

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The purpose of the present work was a study of the effect of age on indices /24* for gas exchange during rest, during orthostatism and under physical load. The study was carried out on 37 practically healthy males with normal physical development and age from 17-72 yr. Group I was composed of persons aged 17-34, total 15, Group II persons aged 35-49, total 16, Group III total 16 ages 50-72. In order to study the effect of sex on gas exchange a comparative study was made with 10 females aged 15-29 and 16 aged 30-49 with normal physical development and no adipose symptoms. Data from the females of these groups were neglected in the calculation of the Tables.

The studies were carried out in the position of rest (recumbent), with an active orthostatic test following 10 min spent by the subject in a standing position during 5 min of physical load on the veloergometer (450 kg/min), in a recumbent position with the trunk at an elevation of 30-40° in its upper portion. In order to study the effect of body build on oxygen consumption the load used was 300 and 600 kg/min. Using the "Spirolit 2" apparatus we determined oxygen consumption, oxygen pulse, oxygen requirement, the Belau recovery coefficient, oxygen consumption for 1 kg of exerted load, and work efficiency. In the venous blood plasma we deter- 25
mined the amount of lactic and pyruvic acid.

The data in Table I indicate that in the state of rest the figure for oxygen consumption in the higher age group is distinctly lower than for persons of Groups I and II. This apparently is associated with the fact that in more advanced age the intensity of metabolism decreases as well as that of the energetic processes.

A reduction in energy process activity as related to age has been demonstrated both in experiment [3, 2, 8] as well as in clinical tests [6]. According to our data, the oxygen pulse value in the state of rest goes down slightly with age.

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* Numerals in the margin indicate pagination in the foreign text.

TABLE I. GAS EXCHANGE INDICES (M±m) FOR PERSONS OF VARYING AGE IN RECUMBENT AND ORTHOSTATIC POSITIONS AND UNDER PHYSICAL LOAD (450 kg/min)

Indices		Group 1	Group 2	Group 3
Rest (horizontal position):				
	oxygen consumption, ml/min/m^2	152±3,9	146±3,1	133±3,0**
	oxygen pulse, ml/beat	4,3±0,2	4,2±0,2	3,9±0,2
	lactic acid, mm/1	1,40±0,12	1,43±0,12	1,38±0,14
	pyruvic acid, mm/1	0,093±0,005	0,86±0,001	0,095±0,006
	lactate/pyruvate ratio	14,7±0,8	16,4±0,9	14,6±1,2
Orthostatic:				
	oxygen consumption, ml/min/m^2	168±3,2	163±3,8	157±3,2*
	%	+10,2±1,7	+11,8±2,1	+18,3±2,0**
	P	0,01	<0,002	<0,001
Physical load:				
	oxygen consumption, ml/min/m^2	689±30	694±18	569±38**
	relative rest increase, %	357±23	376±14	320±28
	oxygen pulse, ml/beat	9,4±0,4	9,±0,3	8,2±0,3**
	relative rest increase, %	119±8	124±10	120±14
	oxygen requirement, ml	1033±39	1172±48	1495∓98**
	recovery coefficient	3,63±0,14	3,40±015	2,83±0,19**
	oxygen consumed per 1 kg/ml	2,16±0,01	2,24±0,03	2,43±0,04**
	work efficiency, %	22,6±0,4	21,8±0,3	20,1±0,3**
	lactic acid, mm/1	2,40±0,26	2,69±0,22	4,76±0,38**
	relative rest increase, %	+78±8	+97±12	+258±29**
	pyruvic acid, mm/1	0,114±0,005	0,123±0,004	0,144±0,009**
	relative rest increase, %	+26±5	+40±18	+52±8*
	lactate/pyruvate ratio	21±1,7	21,6±1,1	33,2±1,9**
	relative rest increase, %	+45±6	+34±9	+136±14**

Remarks: % - average of individual percent displacements
* - reliability of data for Group I
** - same for Group II
P - reliability of displacement in orthostatic position

There was no demonstration of differences caused by age in the amount of lactic or pyruvic acid and in the blood's lactate/pyruvate ratio. In the vertical position oxygen consumption showed a reliable increase in comparison with the horizontal position in all age groups. In the older subjects the increase associated with the recumbent position was significantly larger than for groups I and II. Under physical load oxygen consumption in group III was less and a similar relationship was noted likewise in the figure for oxygen pulse, i. e. oxygen transport at a given cardiac contraction rate was lower. In the opinion of I. M. Muravov (1968), the decrease in oxygen consumption in the process of doing physical work may be associated with a decrease in the physiological reserves of the older organism which results in a narrowing of the range of respiratory reaction during overload. There is no significant difference between groups I and II in the oxygen requirement value but it is higher in group III. There is an age-related drop in the recovery coef-

TABLE II. EFFECT OF BODY BUILD ON OXYGEN CONSUMPTION (M±m) FOR REST AND PHYSICAL LOAD

Oxygen consumption / Body build, $ml/min/m^2$	Rest	Load: 300 kg/min	Load: 600 kg/min
Normosthenic	158 ± 5,8	305 ± 48	856 ± 31
Hypersthenic	177 ± 6,9	672 ± 18,5	940 ± 35
P	$< 0,05$	$0,1 > P > 0,05$	$0,1 > P > 0,05$

ficient, particularly in group III, testifying to the fact that the need for oxygen during actual overload time is met in a lesser degree by older persons than by the young. This is supported by data showing that in the case of group III physical overload resulted in a significantly higher rise in the level of lactic and pyruvic acid and in the blood's lactate/pyruvate ratio, than was true in groups I and II. These data indicate a more significant degree of involvement on the part of the anaerobic processes in supplying energy for physical work. An increase in the degree of anaerobic metabolism is induced by deterioration in the supply of oxygen to tissues and an age-related decrease in the intensity of tissue respiration [5]. We have also shown that the work done by older persons involves greater expenditure of energy than in groups I and II, so that oxygen consumption calculated on the basis of 1 kg of work done is significantly greater in the elderly, while work efficiency is lower.

It has been noted by some authors [4, 10] that body weight affects oxygen consumption during physical overload.

The effect of body build on gas exchange was studied in 40 males divided into 2 groups, differing in respect to number and age distribution, with normal and hypersthenic body build. Table II gives the results for rest and for measured physical overload on the veloergometer.

The data cited show that oxygen consumption in rest and in conditions of different amounts of physical load is lower for persons with a normal body build than for those who are hypersthenic.

The data are contradictory in respect to the effect of sex on oxygen consumption.

Tulius et al. (1967) noted that oxygen consumption values for men and women show only minimal differences in the case of physical load. However Astrand (1960) demonstrated that women require less oxygen than men in physical loading.

Our experiments did not reveal any distinct difference in the amount of oxygen consumed during rest and during physical loading by men and women who were of the same age and the same degree of physical development.

Conclusions /27

1. In the case of the older age group and for normal as compared with hypersthenic persons oxygen consumption during rest and during moderate physical overload diminishes.

2. When the vertical position is assumed oxygen consumption in persons of various age groups is distinctly increased, particularly in the elderly group.

3. With age there is a reduction in the amount of oxygen consumption, oxygen pulse, recovery coefficient, and work efficiency under moderate overload.

4. In persons over 50 physical labor induces a large oxygen requirement and a sharp rise in the level of lactic acid and the blood's lactate/pyruvate ratio.

5. No distinct difference was noted in the amount of oxygen consumed during rest and during physical overload in men and women of the same physical development and age.

Footnote

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