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Short Communication

Sex differences in ventilatory response to carbon dioxide.

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Concerning the sex differences in the ventilatory response to carbon dioxide, contradictory results have hitherto been reported by several investigators; Haywood and Bloete[3] reported that the ventilatory response to 4 to 5% CO_2 inhalation for 5 min was highter in women than in men. However, Rebuck et al.[10] found no significant difference in the slope of the ventilatory response curve between male and female. Similarly, data published by Hirshman et al.[4] show no sex-related differences in hypercapnic drive. On the other hand, other authors have found that females have a lower hypercapnic drive than males [1,5,8]. The present experiments were designed to obtain further information about the difference between males and females with respect to ventilatory response curve to CO_2.

Since Kronenberg and Drage[6] demonstrated that older males had significantly lower hypercapnic drive than young men, the experiments were made on 19 male subjects, aged 18 – 22 years, and 17 female subjects, aged 19 – 22 years, respectively. They are all untrained students who had not participated in any regular physical training for at least few years preceeding these test. The average values of the physical characteristics of both groups are shown in Table 1. Each subjects was briefly informed about the experimental procedure, but not informed about the results of any studies until they had been completed.

Ventilatory response to CO_2 was determined by the rebreathing method after the subject rested at sitting position for 30 min; subjects rebreathed a gas mixture (about 7% CO_2 in O_2) of 5 – 6 liters for 4 minutes as described by Read [9]. A continuous record of alveolar P_{CO_2} (P_{ACO_2}) in the expired gas was obtained by drawing gas from the mouthpiece through an infrared CO_2 analyzer (Capnograph, Godart), then returning it to the rebreathing bag as shown in Fig. 1. Minute ventilation ($\dot{V}_E$) was calculated for succesive 30 second intervals from spirographic recording, and gas volumes were corrected to BTPS conditions. The relationship between P_{ACO_2} and $\dot{V}_E$ are represented by the method of least squares as follow: $\dot{V}_E = S\ (P_{ACO_2} - B)$, where B is the extrapolated intercept in the abscissa (P_{ACO_2} axis) and S is the slope of the line expressed as change in ventilation ($\Delta\dot{V}_E$, liter/min) per unit change in P_{ACO_2} (ΔP_{ACO_2}, mmHg). All probability values were derived by applying the Student t test.

Though the steady state method is a more reliable method than the rebreathing method for studing the ventilatory response to CO_2,

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Table 1. Statistical difference of the mean values of male and female subjects.

	Male (n=19)	Female (n=17)	
Age (years)	20.2 ± 1.2	20.4 ± 0.8	NS
Height (cm)	168.5 ± 3.4	157.9 ± 3.8	***
Weight (kg)	58.8 ± 5.1	51.2 ± 3.9	***
Body surface area (m^2)	1.664 ± 0.078	1.498 ± 0.067	***
Slope (L/min/mmHg)	2.03 ± 1.13	1.23 ± 0.48	*
Slope (L/min/m^2/mmHg)	1.21 ± 0.66	0.81 ± 0.31	*
B (mmHg)	41.0 ± 4.4	40.7 ± 4.3	NS

Values are mean and standard devations.
NS = not significant. ***$p < 0.001$, **$p < 0.01$ *$0.025 < p < 0.05$

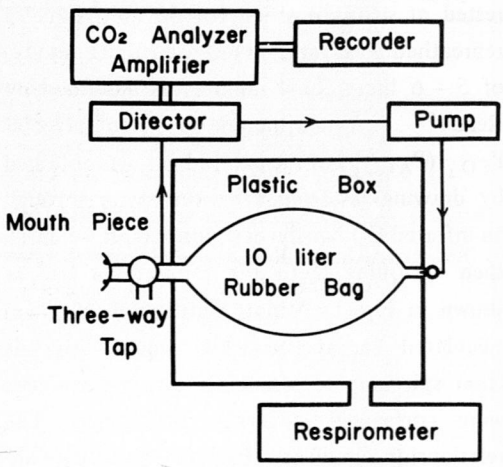

Figure 1. Schematic diagram of experimental set-up.

we used the rebreathing method because the slopes of the response curve at rest were reported to be the same both in the steady state and rebreathing methods[9]. Furthermore, we observed in the previous study[7] that the correlation coefficient between first and second determinations of the slope for each subjects was 0.62. The sensitivity of the respiratory system to changes in P_{CO_2} is probably, therefore, adequately measrued by this techniques.

As described previously, Rebuck et al.[10] and Hirshman et al.[4] have been reported that there were no significantly differences between males and females with regard to hypercapnic drive. It was found in this study, however, that the mean slopes of the males and females were 2.03 and 1.23 l/min/mmHg, respectively; female have a mean value for S that is about 61% of the male's value ($P<0.05$). These results are almost identical with data of Arkinstall et al.[1], Irsigler[5] and Patrick and Howard[8].

The reason for this sex differences in the parameter S, respiratory sensitivity to CO_2, seems so far not to have been considered qualitatively. It might be expected that body size has some influence; resting ventilation in relation to metabolism is the same in meonates as in adults[2] and is therefore related to body size. However, the mean slope of the ventilatory response was again significantly lower in female than in male even if body surface area is considered into the increment of ventilation as shown in Table 1. This is indicating that the sex difference in the slope of venti-

latory response to CO_2 is independent of body size[8]. At present no definite explanation for the lower CO_2 responsiveness in the female subjects obtained here can be presented on physiological ground. The sex difference of hypercapnic drive may be related to various factors such as chemoreceptor function, sympatho-adrenal stimulation, genetic factor, and hormones. However, it will be need further investigation concerning the possibility mentioned above.

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