

# ALVEOLAR AIR CARBON DIOXIDE PERCENTAGE IN INDIAN SUBJECTS

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While carrying out work in the laboratory for demonstration purposes to the students, it was found that most of the alveolar air samples obtained from normal human beings did not contain even 5 per cent carbon dioxide. The present investigation was undertaken to eliminate faults in the technique if any and to obtain the normal values.

## METHODS

The method of Haldane and Priestley (1935) was used. The sample was collected in Bailey vacuum mercury sampling tube and was analysed later in Air Gas Analysis apparatus. All the subjects were drawn from amongst the students and the staff of the Grant Medical College, Bombay. In all 76 observations were made on 39 subjects, 21 of whom were male, while the remaining 18 were female subjects.

Haldane took his samples with subjects at rest. The samples in this work were taken during moderate physical activity.

Prior to collection of the sample each subject was trained for 30 to 45 minutes. In order to obtain an objective proof of the normalcy of the rate and depth of breathing prior to collection of the sample, a stethograph was tied round the chest and a normal stethographic record was taken. The subject was then asked to give the sample while the recording was continued. Any change in the rate and depth of respiration was thus noted giving an objective proof. The tendency to make preliminary deep inspiration or to cause voluntary apnea in an effort to avoid deep inspiration could be easily detected and avoided. The stethographic record also gave an idea about the time required to give out the expiration.

To ascertain the volume of the expired air prior to collection of the sample, the Priestley tube was connected to a spirometer. It was also ascertained that the connection of the spirometer to the tube did not cause any significant change in results.

In all the cases the amount of the air expired was not restricted to 800 ml., but the subject was instructed to breathe out maximally and the sample was collected at the end of maximum expiration only. In most of the cases the limit of 800 ml. was exceeded by an extra value of 500 to 1000 ml. of air.

Most of the samples in this work are collected at the end of normal expiration as judged from the stethographic records.

It was suspected that the operation of the collection of the sample itself might induce some change in the rate and depth of respiration. To overcome this fallacy in many instances the rate of respiration of the subject was measured without his knowledge, and then a metronome was made to ring the requisite number of times per minute, and the subject was made to breathe in and out at the ringing of the metronome before the sample was collected. Even after adopting this procedure no significant difference was found in the composition of the collected alveolar air.

#### RESULTS AND DISCUSSION

The average values obtained for 76 observations and those obtained separately for 18 female and 21 male subjects are given in *Tables* No. I, II and III respectively. It is seen that the values do not differ from each other significantly.

TABLE I  
*Frequency distribution of 76 observations showing percentage of carbon dioxide in alveolar air*

Percentage of CO <sub>2</sub>	Mean	Number of observations	
3.41—3.80	3.60	9*	
3.81—4.20	4.00	11	Mean : 4.64 percent with S. D. : ±0.63
4.21—4.60	4.40	16	
4.61—5.00	4.80	16	
5.01—5.40	5.20	14	
5.41—5.80	5.60	9	
5.81—6.20	6.00	1	

Total : 76

\* One case of 3.30 percent of carbon dioxide has been included in this group.

TABLE II  
*Frequency distribution of 18 female subjects showing the percentage of carbon dioxide in alveolar air*

Percentage of CO <sub>2</sub>	Mean	Number of observations	
3.41—3.80	3.60	2*	
3.81—4.20	4.00	2	
4.21—4.60	4.400	3	Mean : 4.62 percent
4.61—5.00	4.80	8	with S. D. : $\pm 0.4836$
5.01—5.40	5.20	1	
5.41—5.80	5.60	2	

Total : 18

\* One case of 3.30 percent of carbon dioxide is included in this group.

TABLE III  
*Frequency distribution of 21 male subjects showing the percentage of carbon dioxide in the alveolar air*

Percentage of CO <sub>2</sub>	Mean	Number of observations	
3.41—3.80	3.60	3	
3.81—4.20	4.00	2	
4.21—4.60	4.40	5	
4.61—5.00	4.80	3	
5.01—5.40	5.20	5	Mean : 4.68 percent
5.41—5.80	5.60	2	with S. D. : $\pm 0.6772$ .
5.81—6.20	6.00	1	

Total 21



These average values are at least one per cent less than those given by Best and Taylor (1955) viz. 5.5—6.5 per cent. In the procedure adopted here the deviations from the Haldane method gave higher results. There were several reasons for it.

These samples were collected during working hours while the subjects were under moderate physical activity. Under such conditions neither hypoxia of violent muscular exercise (causing a rise in alveolar air carbon dioxide) nor hyperventilation (causing a reduction in alveolar air carbon dioxide) due to afferent muscular impulses could be expected. If the respiratory responses to increased metabolic activity (as in these cases) was correctly adjusted, no variation in the alveolar air carbon dioxide concentration from that during the rest was to be expected.

From the stethographic records it was observed that in most of these cases the time required to give out the expiration was appreciably longer and the percentage of carbon dioxide expected in this type of sampling was much higher than in normal alveolar air.

These samples formed the last part of the forceful maximum expiratory effort. Such samples should inevitably contain more carbon dioxide as compared to those obtained after delivery of 800 ml. of air as described by Haldane. Further, most of these samples were end-expiratory samples only, while Haldane gave average of equal number of end-expiratory and end-inspiratory samples

Thus it will be seen that the samples collected in this work might not be labelled as the normal alveolar air samples in the strictest sense of the designation given by Haldane. But it could be said that most of the deviations from the Haldane method as adopted in this work should give higher results.

Rahn (1949) and Mill (1953) have opined that the Haldane method itself gives higher percentage of carbon dioxide as compared to other more accurate methods. Rieley *et al.* (1946) has proved this fact by simultaneous analysis of blood samples.

In view of these considerations the low results obtained here carry greater significance than that apparently indicated by them. The percentage of carbon dioxide in the Indian subjects should, therefore, be considered as 4.64 per cent which figure is much smaller as compared to the standard text book figures. Sekssena (1958) from Bangalore has communicated an average value of 5.16 per cent of carbon dioxide obtained by him amongst Indian subjects. This figure is also nearer to the value obtained in this work than given by Haldane.

The rate of respiration was noted in 41 out of 76 observations.

TABLE IV

*Frequency distribution of 41 observations showing the alveolar carbon dioxide percentage against the rate of respiration*

Rate of Resp.	Percentage of alveolar carbon dioxide							Total
	3.41 to 3.80	3.81 to 4.20	4.21 to 4.60	4.61 to 5.00	5.01 to 5.40	5.41 to 5.80	5.81 to 6.20	
11—13	—	—	—	—	1	1	1	3
14—16	1	1	—	—	1	1	—	4
17—19	1	1	2	1	3	2	—	10
20—22	—	2	1	5	2	2	—	12
23—26	2	—	3	1	—	—	—	6
26—28	—	—	1	1	—	—	—	2
29—31*	—	1	—	1	2	—	—	4

\* One case of 32 respirations per minute has been included in this group.

The coefficient of correlation between the rate of respiration and the percentage of carbon dioxide comes to—0.2418. Considering the various factors which have not been standardised in this work, this value of the coefficient of correlation must be considered as high. It proves beyond doubt that within the range of the respiratory rate of 11 to 32, and the metabolic conditions such as described in an experiment like this, the percentage of the alveolar air carbon dioxide varies inversely with the respiratory rate. This result can only be explained by taking into account the multitudes of factors controlling respiration (Comroe, 1944).

## SUMMARY

76 observations have been carried out on the percentage of carbon dioxide in the alveolar air, the samples being obtained by a modification of



Haldane—Priestley method in case of 39 normal subjects while under their routine physical activity.

It is argued that the deviation from the Haldane method as adopted in this work is bound to increase the value of the carbon dioxide concentration. Even then it has been observed that the average value obtained (4.64 percent of carbon dioxide) is at least 1 percent less than that given in the text-books (Best and Taylor, 1955) viz. 5.5—6.5 per cent.

It is shown that a possibility exists that the alveolar air carbon dioxide depends upon the respiratory rate under certain conditions.

No relation with age, sex, and “the time interval between food and sampling” could be observed.

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