A STUDY OF TYPES OF RESPIRATORY MOVEMENTS.*

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PLATES XXXIV, XXXV, AND XXXVI.

THE relation of the respiratory movements of chest and abdomen has been several times subjected to investigation with diverse results. Boerhaave † called attention to differences in this respect between males and females in 1744. Hutchinson ‡ observed and made drawings of changes in antero-posterior diameters by throwing the shadow of his subject upon a screen. He applied the terms diaphragmatic and costal to types of respiratory movements, and by these terms he meant not only the amount of excursion, as is generally understood, but the time relations. He stated that the respiratory movements begin with the abdomen in men, and that the increase in antero-posterior diameter passes progressively upward, while in women the phenomena are reversed; and, moreover, that all difficult, sudden, and extraordinary breathing is thoracic in this sense. The increase in depth of abdomen in males shown in his drawings seems to be about two or three times that of the chest, while in females it is only one half to two thirds as great. He observed this preponderance of thoracic movement in twenty-four young girls, and was at a loss to account for it, but suggested that it might be a "reservation against the

* Reported to Boston Soc. Med. Sciences, April 17, 1894, and to the Amer. Assoc. for the Advancement of Physical Education, April 5, 1894. This investigation was begun in 1892, while the author held the Bullard Fellowship in the Harvard Medical School.

† Boerhaave, Praelectiones Academicae, vol. v, sect. 623, p. 144. Edit Haller, Amst., 1744.

‡ Todd's Cyclop. Anat. and Phys., article, Thorax.

period of gestation," thus predicating a specific sexual difference. Mays,* from a study of Indian girls, concludes that the difference between the movements of civilized males is due to differences of constriction. He shows tracings in which the abdominal movement is four or five times the thoracic as typical of the normal relation, and adds " the diaphragm has the power of more than doubling the chest capacity, and it is, therefore, the most essential factor of respiration." Kellogg † gives tracings of males and females having the same general appearance as those shown by Mays, and reaches similar conclusions. Wilberforce Smith,‡ on the basis of a series of observations, decides that there is no sexual difference; Foster, Rosenthal, and Carpenter conclude that a sexual difference exists; Waller and Kirk maintain that any observed differences are due to habits of dress.

Ignoring specific sexual differences, there can be no doubt that dress must interfere with the movements of the diaphragm and the lower ribs in those cases where it takes the form of tightly laced corsets, heavy skirts hung from the waist by bands, and belts tightly drawn or loaded with ornaments. This restricting influence of dress is an immediate effect, and may disappear when the tight bands are removed or loosened. On the other hand, permanent reduction of abdominal movement by constriction must be due to a change in the nervous control of the respiratory muscles toward a new co-ordination requiring less muscular effort.# This change of co-ordination forced upon the motor respiratory centres becomes fixed in habit in proportion to the severity and duration of the constriction and the nervous sensibility of the individual. It is impossible to determine the degree of constriction, since the clothing which produces it will

* An Experimental Inquiry into Chest Movements of the Indian Female. *Therapeutic Gazette*, May, 1887. Breathing Movements as a Cure. *Century Magazine*, August, 1893.

† Experimental Researches respecting the Relation of Dress to Pelvic Diseases of Women. J. H. Kellogg, M. D., *Trans. Mich. State Med. Soc.*, 1888.

‡ On the Alleged Differences between Male and Female Respiratory Movements. *Brit. Med. Jour.*, October 11, 1890.

A preliminary investigation with a belt dynamometer showed that the diaphragm is strengthened rather than weakened by the abdominal resistance offered by corsets, etc.

make difficult the use of recording apparatus, and will render the tracings valueless. For example, a pneumograph over a stiff corset may show no movement while evidences of increased abdominal pressure may be secured by a manometer connected with an air bulb in the rectum (Kellogg). We may take this as evidence that any extra space inside the corset or below it is used in respiration. Again, a pneumograph over folds of thick clothing may not show the real enlargement since part or all of it can be taken up by the clothing. Any record, therefore, with clothing which constricts or cushions the abdomen must be looked upon with suspicion. The immediate interference of dress with the movements of respiration depends so largely upon individual habits in regard to abdominal pressure and the results are so hard to determine for reasons noted above that this study of its influence was limited to the permanent or inhibitive effects, thick clothing and corsets being removed and belts loosened.

In this study simultaneous movements of the thorax and abdomen were recorded by means of belt pneumographs applied over the regions where motion was greatest. No anatomical landmarks were used, for it was soon found that there was considerable individual

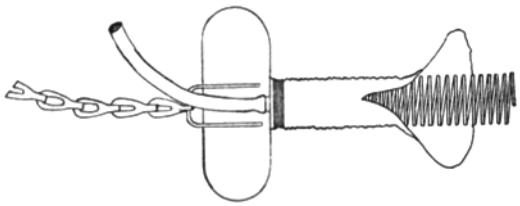


FIG. 1.—Belt-pneumograph, showing structure.

variation in the level of greatest movement. Two pieces of thin rubber tubing, each about fifteen inches long and one inch in diameter, were made into pneumographs (Fig. 1) by the insertion of light coils of wire,* and the addition of a chain by which they were held in place around the body and adjusted for varying circumferences. One end of the tube was closed, the other connected by smaller tubing

* Suggested by Dr. F. W. Ellis.

with a modification of the Ellis piston recorder (Fig. 2), which made tracings corresponding to variations in girth. On account of the length and elasticity of the tubing, the pressure of the pneumograph was too slight to be noticed, all enlargement was faithfully taken up, there was no inelastic resistance and no difficulty or delay in adjusting it to any subject. The calibre of the pneumographs and of the piston recorders was approximately the same, the depth of the tracing was, therefore, the same as the increase in girth.

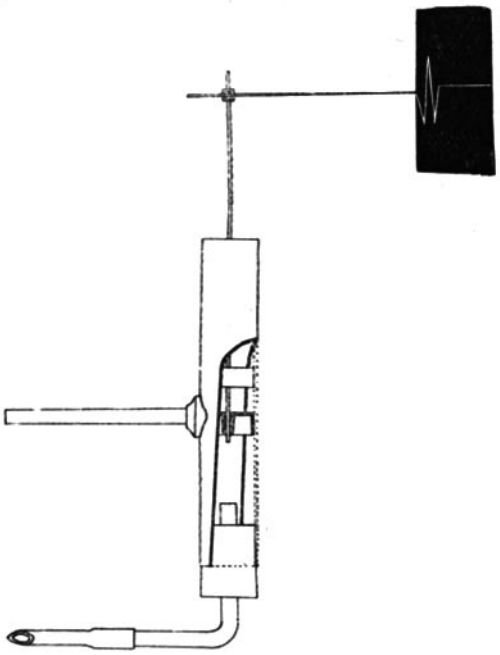


FIG. 2.—Piston recorder, modified for respiratory tracings, and portion of tracing.

A series of calibration tests made upon two subjects to determine the amounts of air moved by chest and abdomen respectively, when acting alone, gave the following results:

	Normal chest girth.	Normal abdominal girth.	VOLUME OF AIR MOVED BY 10 MM. INCREASE.	
			Chest.	Abdomen.
F.	101·0 cm.	87·0 cm.	780 c. c.	409 c. c.
M	85·5 "	71·2 "	517 "	357 "

The volume of air introduced by thoracic movement was to that introduced by the abdominal as 1:0.52 for one subject, and as 1:0.68 for the other.

Five movements of the piston recorders corresponding to the increased girth of thorax and abdomen in five successive respirations

of each individual were measured in millimetres. That part of the tracing was chosen for measurement in which the movements were most regular, and seemed to be most characteristic. To avoid confusion arising from individual variations in depth of respiration, the relation of thoracic to abdominal movement is expressed in the form of a ratio secured by dividing the number representing the chest increase by the number representing the abdominal increase; thus, $\frac{\text{Th } 15}{\text{Ab } 20} = 0.75$. The respiratory ratio is less than unity for all individuals in whom the abdominal movement is greater than the thoracic, and greater than unity in all those in whom the abdominal movement is less. The records are arranged in the tables according to the value of the respiratory ratios $\frac{\text{Th}}{\text{Ab}}$.

The conclusions of this paper are drawn from a study of four hundred and seven respiratory tracings secured from boys and girls, young men and young women, and from individuals of various races found in Chicago during the World's Columbian Exposition.*

Lack of space makes it impossible to publish the complete series of records, but in Tables I to IV are given the individuals of certain groups, selected because they are typical or contribute elements which have been considered factors in determining respiratory types. In each table the records are arranged according to the value of the respiratory ratios, beginning with the lowest. The sums of five consecutive thoracic movements, those of the corresponding abdominal movements and the respiratory ratios are entered in parallel columns with certain other items, as age, childbearing, corset-wearing, etc.

Plates XXXIV to XXXVI † contain distribution curves plotted

* This opportunity is taken to express appreciation of the kind assistance rendered by the managers of various amusement enterprises of the Midway Plaisance, among which may be mentioned the Samoan Village, the Turkish Theatre, the Bedouin Village, the Bedouin Encampment, the Eskimo Village, the Streets of Cairo, the Javanese Village; and also by the manager of a group of Hawaiian dancers which was in Chicago during the summer of 1893, and by Mr. Salisbury, of "Buffalo Bill's Wild West."

† The mean is shown by the apex of the curve; the median, by a heavy vertical line intersecting it.

for each group, the unit of distribution being a difference of 0.5 in respiratory ratio. The curves contain all the records with respiratory ratios less than 4.25 in value, and the percentage of the observations having ratios higher than 4.25 is represented by a vertical line at the end of the curve. As may be seen by reference to Curves I, III, and V, very symmetrical curves of distribution have resulted with only moderate numbers of observations. This leads us to the conclusion that a type of breathing exists which will be true for the majority of any large natural group in spite of individual variations in ratio and depth. Curve VII is an attempt to secure a distribution curve for the respiratory ratios of those females who gave a direct history of constricting dress. It will be seen that there is no mean even with the large unit of distribution. A certain proportion of the ratios fall at various points between 0.0 and 4.25, and, as may be seen by reference to Table III, the ratios above 4.25 (forty-three per cent of the total) were scattered even more irregularly than were those below. We judge, then, that the effect of constriction to the abdomen, not necessarily by corsets and in our subjects very rarely so produced, is to diminish the proportionate movement of the abdomen, and to destroy the natural grouping of the individuals so affected. To show that the unit of distribution chosen is abundantly large, it may be stated that a smooth curve of distribution results in the case of schoolboys and college men with a unit of 0.2 in place of the one of 0.5 which we have used. Curves VI and VIII show the distribution curves of two classes of constricted individuals, Curve VI from the records of twenty-four male Syrians (Bedouins, Turks, etc.) and Curve VIII from the tracings of fifty-two American women, both mixed so far as the effects of constriction are concerned. The abdominal movements of the Syrians had been restricted by tight swathing in childhood and long, tightly wound belts in adult life, while many of the American women had similarly interfered with their respiratory movements by corsets and skirt bands. Certain individuals in both groups were known not to have been seriously constricted, but it was impossible to separate them from the constricted on the evidence available. The curves are flat, a certain proportion of

the ratios occur above the limit and the means are decidedly higher than in Curves I and III. There is a great contrast between these and Curve VII and this would seem to be due to the fact that both constricted and unconstricted individuals are included in the former. The differences between these curves and those for clearly unconstricted groups will be seen in Curve IX on which the curves of schoolboys, college men, constricted males and American women have been plotted for direct comparison. Nearly the same percentages of the four groups have ratios at $\frac{Th}{Ab}$ 1.0, the mean for the two groups under consideration, and we may consider that those percentages corresponding to the portion of the unconstricted groups outside of the lower part of the constricted curves have been pushed into the upper part of the curves and beyond by the constriction. It would seem, therefore, that the occurrence of an apparent mean for the Syrian men and American women at a higher value of the respiratory ratio than for college men is probably due to the combination of respiratory ratios of unconstricted individuals who have naturally a greater relative movement of the thorax than the average, with ratios of others in whom constriction has changed the respiratory co-ordination to a higher level. We are thus forced to regard the means in these curves as having no value in determining the natural relation between thoracic and abdominal movements in respiration.

The remaining curves (II and IV) also show the presence of constriction. The principal evidence in Curve II is the higher level of the mean and the greater breadth of the top of the curve. In Curve IV the mean is at a lower value than in Curve II, but the curve beyond the mean drops much more slowly than in an unconstricted group. A small percentage of ratios in each case falls outside the limits. The absence of notable constriction caused both groups to be regarded as unconstricted, but the analysis of the distribution curves shows that this is not true and proves that even an inelastic string * tied about the waist may modify the respiratory ratio.

Types of Respiration.—Respiratory tracings have been published

* Such as worn by the South Sea Island men, etc.

as typical of male respiration in which the abdominal movement was from two to five times as extensive as the thoracic, and as typical of the female type tracings in which the chest movement was correspondingly greater. This "female type" Mays and Kellogg have demonstrated to exist among civilized women only in whom constriction by corsets has effected a change in the natural relation of the movements. These tracings suggested the analysis of the groups into three parts (Table V): Those in whom the abdominal movements were at least double the thoracic; those in whom the thoracic were at least double the abdominal; and those lying between these extremes. In this table the first column shows the total number of observations for the special groups; the second, the percentage of those whose ratios fall below one half; the third, the percentage of those whose ratios fall between one half and two; and the fourth column, the percentage of those whose ratios fall above two. It is interesting to note that the respiratory ratio in the greater percentage of males and females lies between 0.5 and 2.0. Seventy-five per cent of the forty-four females from the World's Fair who gave a history of having worn constricting dress show a thoracic movement two or more times as great as the abdominal. In no other group, however, do we find so large a proportion as this and it is among the Syrian men from whom we got a history of constricting dress that we find the nearest approach to it (forty-two per cent). Among these men, however, fifty per cent of the ratios fall between 0.5 and 2.0. In the last two columns of Table V will be found the percentages of those whose ratios fall below and above unity. Schoolboys, college men and males with unconstricting dress show a distinct tendency to an excess of abdominal movement. Females with constricting dress give a large proportion of thoracic movement; American women a moderate preponderance; schoolgirls, females with unconstricting dress and males with constricting dress have about equal numbers in each group.

The Male Type.—In the records of schoolboys and college men we have the best evidence at our disposal of the normal type of male respiration. The mean value of the respiratory ratio for each of these curves occurs at 0.5, the median value for the groups being 0.63 and

0.65 respectively. In the curve of unconstricted males it may be noted that the mean respiratory ratio is at a distinctly higher point than in the curve of American men; but, since these records are not consistent with the others, it seems best to base our conclusions upon results obtained from the larger groups on the ground that the discrepancy probably is due either to the small number of observations (twenty-two) or to slight constriction by waist cords or bands. It appears, therefore, that the normal type of respiration for males is one in which the thoracic movement is between one half and two thirds as great as the abdominal.

Effect of Constriction.—The change produced by constriction of the abdomen has been noted in the study of Curves II, VI, VII, and VIII. The apparent effect in any group, every member of which has been subjected to a considerable degree of constriction, is to destroy the normal relation between thoracic and abdominal movements and to cause for each individual an irregular diminution of the abdominal movement in proportion to the extent of the constriction and the sensitiveness of his nervous co-ordination.

Sexual Differences.—We have noted evidences of constriction in each of the distribution curves of females. The mean value of the respiratory ratios secured from the Midway females with unconstricting dress (Curve IV) is 0.5, the same as that for schoolboys and college men. In these females the evidence of constriction is to be found in the less rapid fall of the curve above the mean, which raises the median value for the group to 1.12. The mean for schoolgirls and American women is 1.10, the median being 1.02 and 1.25 respectively.

A comparison of the males with constricting dress and the American women is of value since these two groups are practically identical in respect to constriction, each containing individuals whose respiratory movements have been practically unconstricted and others who have been bound. The statement that they have been considered constricted on the basis of inquiry into their mode of dressing, and not from a study of the tracings, may need repetition. Their distribution curves (VI and VIII) and percentages in Table V show the

same characteristics, and this correspondence seems to indicate that the inhibiting influence of dress is in result the same in males and females and, as a corollary, that the natural breathing is the same in both. All the evidence goes to prove that constriction is very effective in changing the relation between thoracic and abdominal movements in respiration, but that sex has played no part in producing the differences in type which have been attributed to it.

Age.—In Table I the ages of the schoolboys are given. The larger number of the younger boys is found among the first seventeen of the thirty-five in the group, demonstrating for them a greater proportionate abdominal excursion. A similar predominance may be found in schoolboys as compared with the college men, for sixty-six per cent of the schoolboys are included within the largest group of respiratory ratios, while only fifty-two per cent of the college men fall within the same limits. In Table II we find that the few young children are easily within the first half of the table. These facts may be explained either by the greater tendency in childhood to depend upon ligamentous support of trunk and head and the use of the diaphragm exclusively for breathing, which tendency is lost when the conventional ideas of form are developed resulting in an erect carriage with full muscular support; or by the presence of constriction sufficient to interfere with the respiratory co-ordination.

Childbearing.—That childbearing has little permanent effect upon the respiratory ratio may be seen from Tables II and III, in which the records of women who have borne children may be found distributed throughout the tables. Any tendency to thoracic breathing inherited as a "reservation against the period of gestation" would certainly be increased by the repeated occurrence of such condition.

*Correlation.**—In Table VI will be found an attempt to determine the correlation between respiratory ratios and certain physical measurements of groups for which they were obtainable. The numbers which appear in the columns Height, Weight, etc., are the aver-

*** Dr. Dudley A. Sargent, Director of the Hemenway Gymnasium of Harvard University, kindly furnished the anthropometric data included in this table.**

ages of the measurements of individuals in the groups indicated by the limiting values of $\frac{Th}{Ab}$. The numbers in parentheses accompanying these give the number of individuals in each group. Heights, girths and depths are given in centimetres; weight in kilogrammes; capacity of lungs in cubic inches. Total strength is conventional and is obtained by adding together the strength of lungs, back, legs, forearm, and a value for strength of upper arm obtained by multiplying the number of times the person can pull himself up and push himself up into one tenth of his body weight.

The table shows that there is some relation between the respiratory movements and the various measurements. In the college students the chief thing to be noticed is that those who have a ratio $\frac{Th}{Ab}$ 0.8 to 1.2 are the largest men in every way. A comparison of the average measurements, lung capacity, girth of chest, etc., with those of the other groups shows that they are related directly as their heights, that is, are large men, and have other measurements in proportion. Of the American women, those who breathe abdominally are heavier, and have correspondingly greater measurements, while those with chest movement in excess are lighter and have smaller measurements. There is here again a suggestion of the physical superiority of the group $\frac{Th}{Ab}$ 0.8 to 1.2.

It is not possible to emphasize more strongly the results of this study of correlation because of the large average variation and the small number of observations for analysis, but at some future time more may be attempted in this direction.

Conclusions.

1. Children of the two sexes differ very little in the character of their respiratory movements.

2. Between girls and women and boys and men there is little or no difference in respiratory type.

3. Childbearing does not permanently affect respiration.

4. The natural type of respiration for both sexes is one in which the movement is fairly equally balanced between chest and abdomen, the abdominal being somewhat in excess.

5. In typical unconstricted individuals the chest contributes about the same bulk of air as does the abdomen.

6. Constricting dress causes preponderance of thoracic movement in ratio to its restriction of abdominal movement and to the sensitiveness of the nervous co-ordination.

Acknowledgments are due to Prof. H. P. Bowditch for suggestions; to Prof. F. W. Putnam and Colonel Bidlake, of the Ethnological Department, World's Columbian Exposition, Dr. J. F. Jones, Dr. Jane D. Kelly, and Miss Helen P. Howell for assistance in securing records; and especially to Mr. G. W. Moorehouse, formerly Assistant in Physiology, for valuable assistance in getting records and in calculating and plotting results.

TABLE I.

Thirty-five Schoolboys. Average Age, Nine Years Eight Months. Range, Six to Fifteen Years

No.	Age.	RESPIRATORY MOVEMENTS IN MM.		$\frac{Th}{Ab}$	No.	Age.	RESPIRATORY MOVEMENTS IN MM.		$\frac{Th}{Ab}$
		Thorax.	Abdomen.				Thorax.	Abdomen.	
1	8	5·0	19·0	0·26	19	12	15·0	25·0	0·60
2	7	15·0	52·0	0·29	20	10	11·0	17·0	0·65
3	6	7·0	14·0	0·29	21	12	29·0	44·0	0·66
4	9	7·0	20·0	0·35	22	9	29·0	43·0	0·68
5	7	10·0	27·0	0·37	23	..	31·0	45·0	0·69
6	..	10·0	27·0	0·37	24	6	18·0	22·0	0·82
7	7	9·0	22·0	0·41	25	10	14·0	16·0	0·88
8	12	9·0	21·0	0·43	26	7	15·0	17·0	0·88
9	7	13·0	30·0	0·43	27	14	28·0	31·0	0·90
10	8	9·0	24·0	0·47	28	6	16·0	17·0	0·94
11	6	12·0	23·0	0·52	29	11	24·0	24·0	1·00
12	10	11·0	21·0	0·52	30	14	30·0	29·0	1·04
13	14	13·0	24·0	0·54	31	..	71·0	66·0	1·08
14	8	12·0	22·0	0·55	32	15	33·0	28·0	1·18
15	9	11·0	20·0	0·55	33	11	27·0	12·0	2·25
16	13	15·0	27·0	0·56	34	10	66·0	23·0	2·87
17	8	12·0	21·0	0·57	35	12	66·0	7·0	9·43
18	..	12·5	21·0	0·60					

TABLE II.

Thirty-four Females. Unconstricting Dress. (Midway Plaisance.)

Number.	Race.	Age.	Children.	RESPIRATORY MOVEMENTS IN MM.		$\frac{Th}{Ab}$
				Thorax.	Abdomen.	
1	Es.	4	..	0·0	7·0	0·00
2	Es.	3	..	2·0	11·5	0·17
3	Es.	5	..	4·5	18·0	0·25
4	Sy.	45	6	4·0	10·8	0·37
5	I.	15	..	8·0	20·0	0·40
6	Es.	7	..	4·0	10·0	0·40
7	I.	8	..	5·0	11·8	0·43
8	H.	24	2	10·0	22·5	0·45
9	Sa.	19	..	9·0	18·6	0·48
10	I.	11	..	9·0	16·0	0·56
11	I.	26	3	15·0	23·0	0·65
12	H.	21	..	20·3	29·0	0·72
13	J.	18	1	9·0	12·0	0·75
14	Sa.	..	..	7·0	9·3	0·75
15	I.	50	3	11·0	14·5	0·76
16	Eg.	15	..	8·5	11·0	0·77
17	Es.	18	..	12·0	13·0	0·93
18	H.	19	..	12·2	12·0	1·02
19	J.	17	..	16·0	13·0	1·23
20	I.	60	9	8·3	6·5	1·28
21	I.	20	..	16·5	12·0	1·38
22	Es.	55	2	14·0	10·0	1·40
23	Sa.	17	..	12·0	8·6	1·40
24	I.	18	..	15·0	10·0	1·50
25	H.	20	..	17·0	11·0	1·54
26	I.	21	4	22·5	12·6	1·79
27	Es.	39	..	24·0	13·0	1·85
28	Sa.	15	..	10·0	5·3	1·89
29	Es.	40	11	15·0	7·8	1·94
30	Es.	14	..	12·0	5·0	2·40
31	I.	28	..	20·5	7·0	2·93
32	Sy.	26	..	6·0	2·0	3·00
33	Es.	13	..	20·5	6·0	3·41
34	I.	30	2	24·5	3·0	8·17

Es. = Eskimo. Eg. = Egyptian. Sy. = Syrian. I. = American Indian.
Sa. = Samoan. H. = Hawaiian. J. = Javanese.

TABLE III.

Forty-four Females. Constricting Dress. (Midway Plaisance.)

Number.	Race.	Age.	Children.	RESPIRATORY MOVEMENTS IN MM.		$\frac{Th}{Ab}$
				Thorax.	Abdomen.	
1	Eg.	20	..	5·6	11·5	0·48
2	Eg.	15	..	11·0	10·0	1·10
3	Es.	30	8	10·0	9·0	1·11
4	Eg.	17	..	5·0	4·0	1·25
5	Sy.	32	..	17·0	12·5	1·36
6	Eg.	23	..	11·6	7·6	1·53
7	Es.	45	13	11·0	7·0	1·60
8	Sy.	16	..	8·5	5·0	1·70
9	Es.	17	..	21·0	12·3	1·71
10	J.	15	..	17·0	8·0	2 13
11	Sy.	28	3	15·0	7·0	2·13
12	Sy.	21	2	11·5	5·0	2·30
13	Es.	18	..	16·0	7·0	2·30
14	Es.	16	..	14·0	6·0	2·33
15	Sy.	35	..	12·0	5·0	2·40
16	Sy.	13	..	13·0	5·0	2·60
17	I.	31	1	21·0	8·0	2·62
18	Es.	16	1	11·0	4·0	2·75
19	Es.	17	..	16·0	5·0	3·20
20	Eg.	25	..	20·0	6·0	3·33
21	Es.	35	3	10·3	3·0	3·43
22	J.	18	1	7·3	2·0	3·65
23	J.	20	..	8·0	2·0	4·00
24	Es.	14	..	25·0	6·0	4·17
25	Sy.	32	2	8·5	2·0	4·25
26	Es.	24	..	23·0	5·0	4·60
27	Es.	28	..	14·2	3·0	4·73
28	Sy.	40	4	24·0	5·0	4·80
29	Eg.	25	..	10·0	2·0	5·00
30	Sy.	21	..	31·0	6·0	5·16
31	J.	30	..	11·0	2·0	5·50
32	Sy.	18	..	11·0	2·0	5·50
33	Eg.	10	..	16·0	2·0	8·00
34	J.	48	4	16·6	2·0	8·30
35	J.	..	1	22·0	2·0	11·00
36	I.	45	1	33·3	3·0	11·10
37	Sy.	17	..	25·0	2·0	12·50
38	Sy.	40	8	35·5	2·0	17·75
39	J.	..	..	12·0	....	∞
40	J.	23	..	12·3	....	∞
41	I.	42	..	13·5	....	∞
42	J.	30	1	15·0	....	∞
43	Sy.	16	..	15·0	....	∞
44	J.	..	..	16·5	....	∞

Eg. = Egyptian. Es. = Eskimo. Sy. = Syrian. J. = Javanese. I. = American Indian.

TABLE IV.

Fifty-two American Women. Average Age, Twenty-two Years Five Months. Range, Seventeen to Thirty-four Years.

No.	Age.	Corset.	RESPIRATORY MOVEM'TS IN MM.		Th/Ab	No.	Age.	Corset.	RESPIRATORY MOVEM'TS IN MM.		Th/Ab
			Thorax.	Abdomen.					Thorax.	Abdomen.	
1	21	No.	2·0	19·0	0·11	27	20	No.	35·0	28·0	1·25
2	17	No.	6·0	14·0	0·43	28	19	3 (2)	55·0	44·0	1·25
3	19	4	15·5	36·0	0·43	29	18	Yes.	23·0	17·3	1·33
4	19	1½	14·0	30·0	0·47	30	25	Yes.	39·0	29·0	1·35
5	24	Yes.	11·0	22·5	0·49	31	25	No.	18·0	13·3	1·36
6	19	No.	21·0	40·0	0·53	32	34	No.	46·0	29·0	1·59
7	21	W.	37·5	62·7	0·60	33	20	No.	16·0	10·0	1·60
8	26	11	22·0	33·0	0·67	34	31	No.	24·5	15·0	1·63
9	..	....	15·7	22·0	0·71	35	25	No.	27·0	16·0	1·69
10	25	No.	27·5	37·7	0·73	36	..	No.	28·7	16·0	1·79
11	22	9 (3)	26·0	31·7	0·82	37	22	No.	23·0	11·0	2·10
12	28	No.	12·0	14·3	0·84	38	..	....	25·0	11·0	2·28
13	23	3 (2)	19·3	21·3	0·91	39	30	Yes. (3)	16·0	7·0	2·29
14	24	No.	55·0	59·0	0·93	40	..	....	61·0	25·5	2·39
15	24	No.	20·0	21·0	0·95	41	25	9	75·0	25·0	3·00
16	21	W.	23·0	23·3	0·99	42	20	No.	47·0	15·0	3·13
17	25	No.	13·7	13·3	1·03	43	18	2 (2)	15·7	5·0	3·14
18	..	....	14·7	14·0	1·05	44	..	....	26·0	5·0	5·20
19	24	Yes.	8·0	7·5	1·07	45	19	No.	54·7	9·0	6·08
20	19	1 (2)	17·8	16·0	1·11	46	17	No.	38·0	6·0	6·33
21	20	No.	27·0	23·7	1·14	47	28	3 (3)	74·0	11·0	6·73
22	18	3	19·0	16·0	1·19	48	28	1 (6)	95·0	14·0	6·80
23	21	No.	21·7	18·3	1·19	49	17	Yes.	77·0	10·0	7·70
24	20	Yes (2)	31·5	26·3	1·20	50	17	2	19·0	....	∞
25	25	12	22·5	18·7	1·21	51	20	No.	23·0	....	∞
26	32	12	21·0	17·0	1·24	52	25	No.	66·0	....	∞

Yes = Corset worn, length of time not stated. 4 = Corset worn for four years. (3) = Discontinued wearing corsets three years ago. W = Corset waists worn. No = Never wore corsets.

TABLE V.

Percentage Distribution of Observations in relation to $\frac{Th}{Ab}$.

GROUP.	No. of observations.	RATIOS.				
		0·0 to 0·5.	0·5 to 2·0.	2·0 to ∞.	0·0 to 1·00.	1·0 to ∞.
Schoolboys	35	28·6	62·8	8·6	82·8	17·2
Schoolgirls	72	1·4	83·3	15·3	52·7	47·3
College men	124	27·4	66·9	5·7	78·0	22·0
Females unconstricted	34	26·5	58·7	14·8	50·0	50·0
Males unconstricted	22	13·7	81·7	4·6	72·8	27·2
Males constricted	24	8·3	50·0	41·7	41·6	58·4
Females constricted	44	2·3	22·6	75·1	2·3	97·7
American women	52	9·6	59·6	30·8	30·8	69·2

TABLE VI.

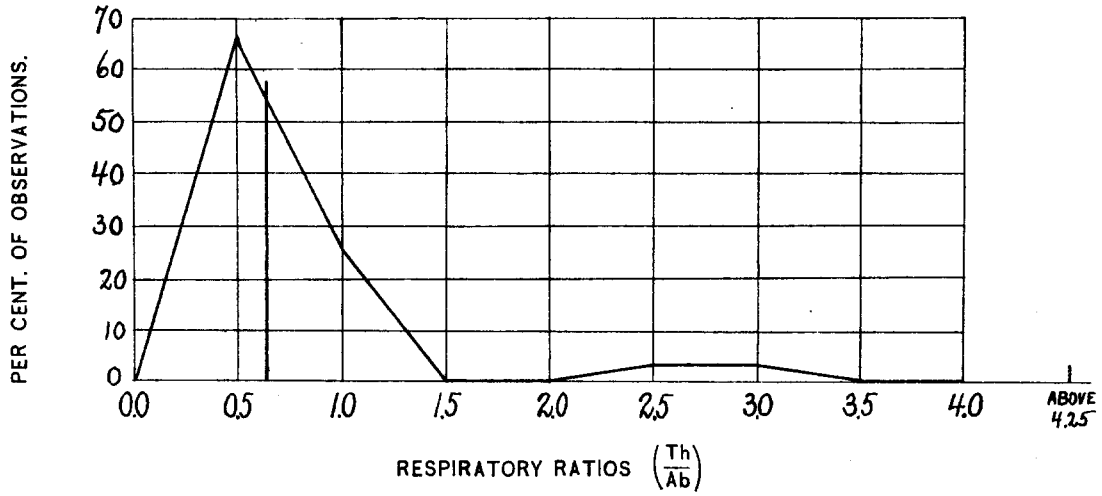
Correlation.

	$\frac{Th}{Ab}$	Height.	Weight.	Capacity of lungs.	Total strength.	CHEST NORMAL.			ABD. NORMAL.	
						Chest at rest.	Increase in respiration.	Depth.	Girth.	Depth.
College men.	0·0–0·4	173·0 (15)	64·3 (15)	256·0 (14)	493·0 (14)	87·6 (15)	5·03 (15)	18·7 (15)	73·5 (15)	18·3 (15)
	0·4–0·8	172·7 (40)	62·4 (40)	254·0 (39)	468·3 (39)	86·1 (40)	5·25 (40)	18·9 (40)	72·2 (40)	18·3 (40)
	0·8–1·2	175·2 (13)	65·3 (13)	270·5 (13)	525·9 (13)	88·2 (13)	5·2 (13)	20·4 (13)	68·7 (13)	18·6 (13)
	1·2–2·0	174·2 (15)	61·4 (15)	245·3 (15)	470·4 (15)	85·5 (12)	5·2 (15)	18·5 (15)	71·0 (15)	18·0 (15)
	2·0–4·0	173·0 (6)	59·0 (6)	258·3 (6)	473·7 (6)	83·1 (6)	5·9 6)	18·4 (5)	69·9 (5)	18·0 (5)
American women.	0·0–0·8	160·3 (6)	57·4 (6)	152·0 (5)	.....	80·6 (5)	5·3 (5)	17·3 (5)	64·3 (5)	18·8 (5)
	0·8–1·2	161·0 (5)	55·2 (5)	166·6 (5)	.....	78·2 (5)	5·5 (5)	17·3 (5)	62·6 (5)	16·5 (5)
	1·2–6·0	160·0 (5)	50·5 (5)	139·0 (5)	.....	77·7 (5)	4·3 (5)	15·7 (4)	59·8 (5)	15·0 (4)
	6·0+	160·6 (7)	46·6 (7)	130·4 (7)	.....	72·4 (7)	4·2 (7)	16·2 (7)	58·7 (7)	14·9 (7)

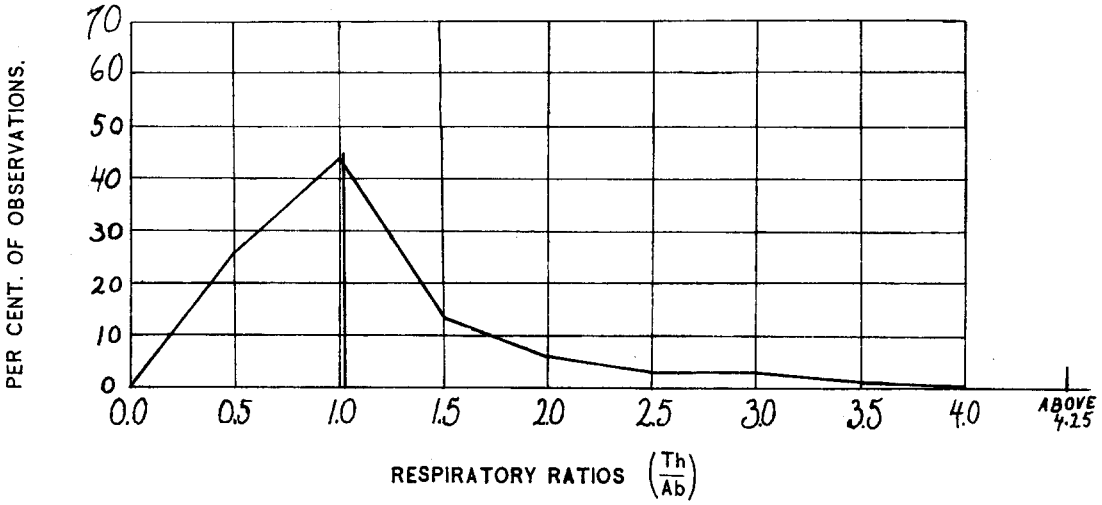
DESCRIPTION OF PLATES XXXIV, XXXV, AND XXXVI.

See text (p. 680 et seq.).

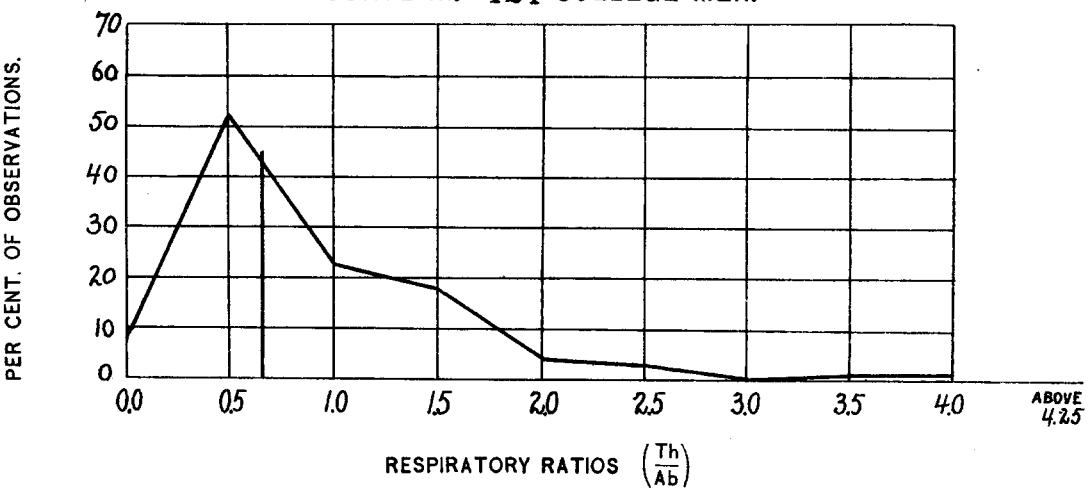
CURVE I. 35 SCHOOL BOYS.



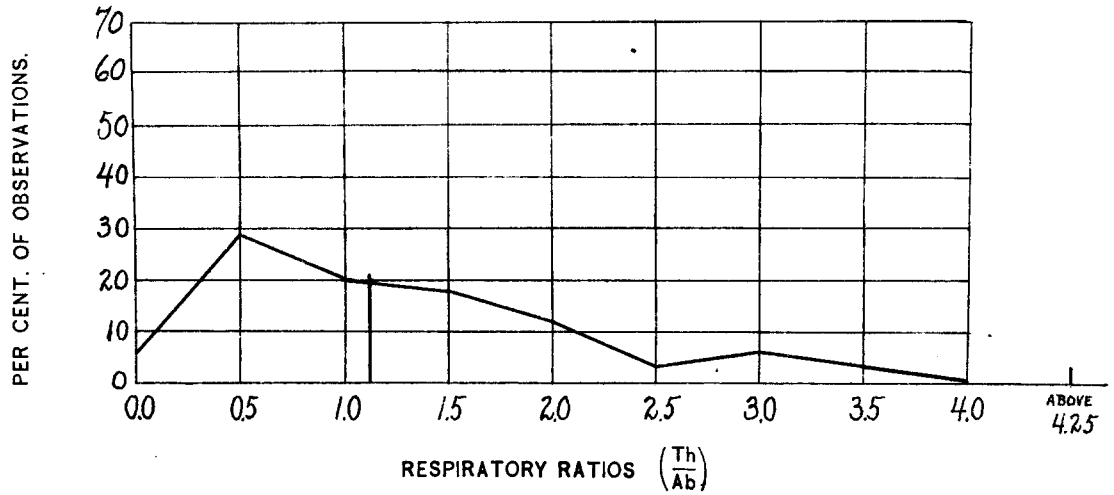
CURVE II. 72 SCHOOL GIRLS.



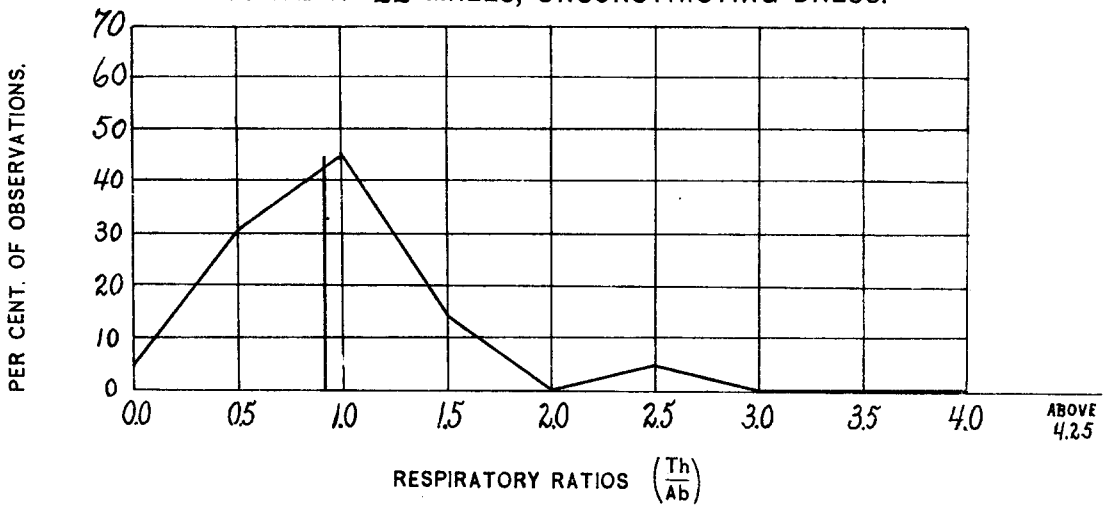
CURVE III. 124 COLLEGE MEN.



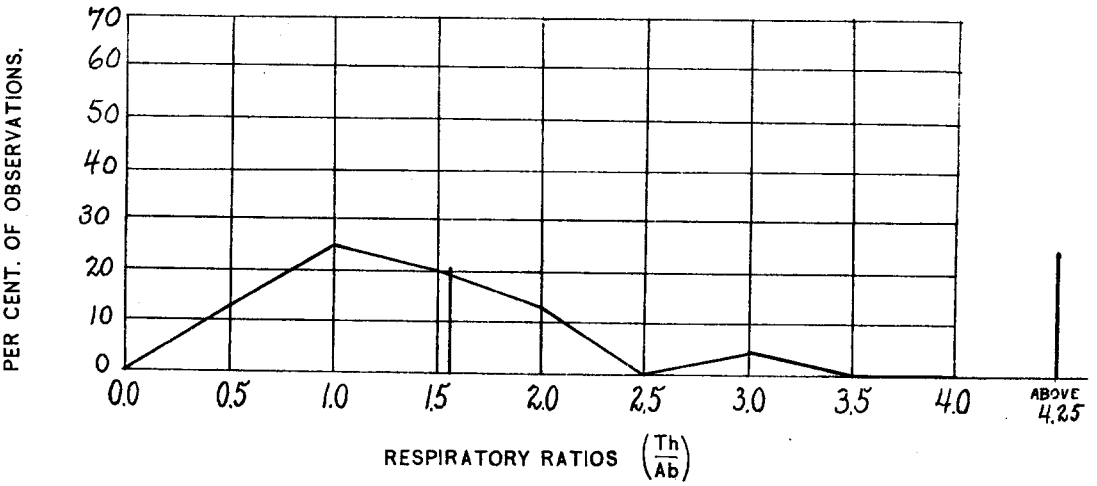
CURVE IV. 34 FEMALES, UNCONSTRICTING DRESS.



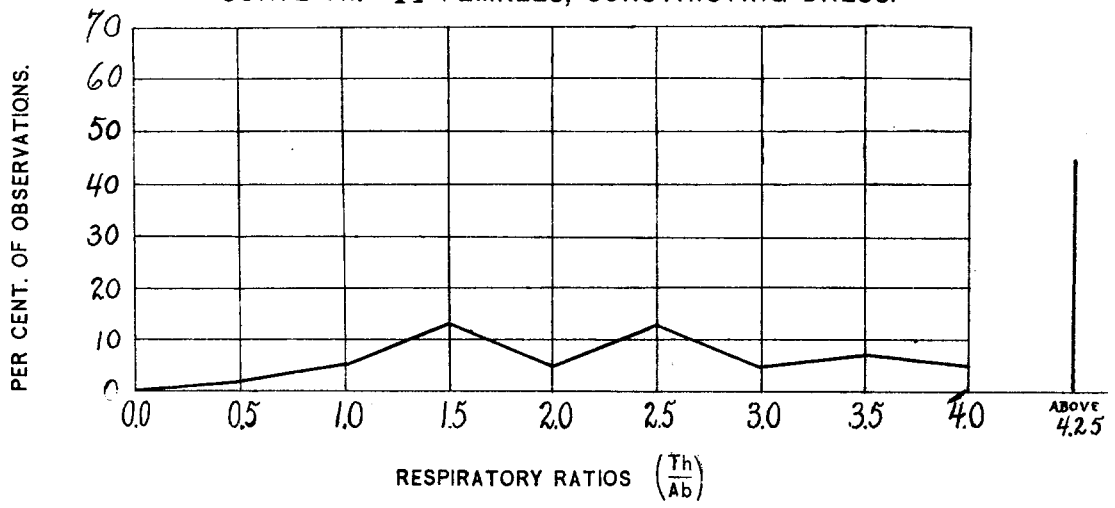
CURVE V. 22 MALES, UNCONSTRICTING DRESS.



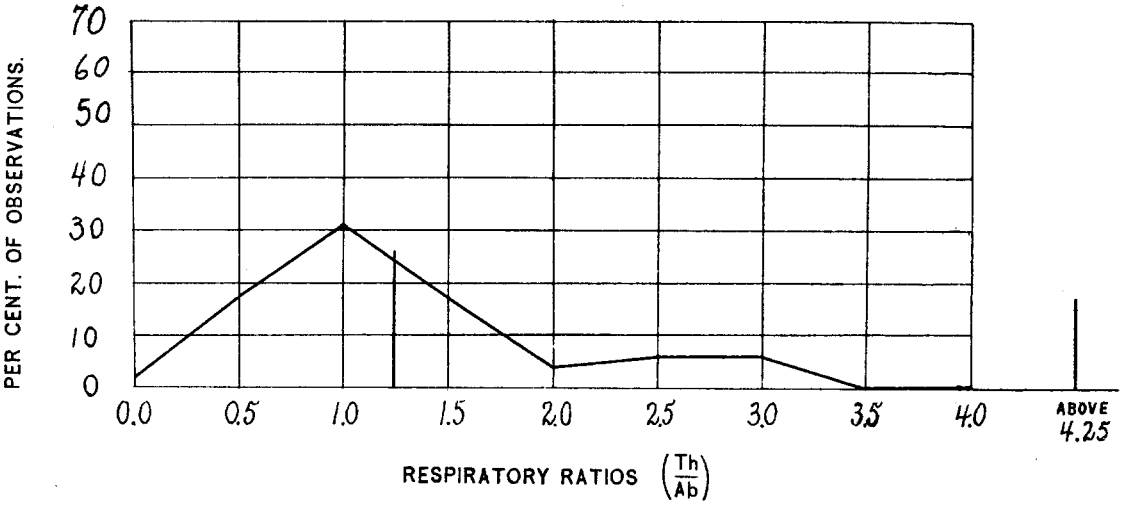
CURVE VI. 24 MALES, CONSTRICTING DRESS.



CURVE VII. 44 FEMALES, CONSTRICTING DRESS.



CURVE VIII. 52 AMERICAN WOMEN.



CURVE IX.