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AN OCCUPATIONAL STUDY

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The use of the spirometer as a clinical instrument of precision, introduced by Jonathan Hutchinson in 1846, has been brought into more general use through the more recent researches of Peabody,¹ Wentworth,² Dreyer,³ West,⁴ Wilson, Edwards,⁵ Lundsgaard, Van Slyke,⁶ Hewlett and Jackson⁷ and others. The normal standards suggested by Hutchinson have been modified, and the relation to the body measurements of height, weight, body surface, chest volume and circumference have been determined for various groups of persons.

The value of spirometry as an index to the patient's clinical condition has already been demonstrated in cardiac⁸ and pulmonary disease.⁹ Conditions necessary for the more general adoption of this method are: (1) a simple technic; (2) accurate normal standards with knowledge of the normal range, and (3) knowledge of the factors influencing vital capacity. The first is fairly standardized, and although the apparatus is cumbersome and not easily portable, it is easy to manipulate and accurate, provided the cooperation of the patient can be obtained. Normal standards for men, women and children have been investigated, and figures representing the ratios of vital capacity to body surface

*From the Department of Medicine, Hunan-Yale College of Medicine.

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9. Wittich, F. W.; Meyers, J. A., and Jennings, F. L.: J. A. M. A. **75**:1249 (Nov.) 1920. Dryer, G., and Burrell, L. S. T.: Lancet **1**:1212, 1920. Cameron, C.: Tubercle **3**:385 (June) 1922, Abstr. J. A. M. A. **79**:246 (July) 1922.

and to height, in terms of liters per square meter of surface and in cubic centimeters per centimeter of height, have been adopted. West,⁴ after an analysis of eighty-five medical students and forty-four nurses, decided on 2.5 liters per square meter body surface for men and 2 liters for women as a normal. A ratio of 25 c.c. per centimeter of height for men and 20 c.c. for women was also proposed; men with an athletic history were given 2.8 and 29 as surface and height ratios, respectively. Wilson and Edwards,⁵ from a study of 362 school children in New York City, adopted standards for children of 1.93 for surface and 15.5 for height ratios.

Clinical studies and reports are leading to a clearer understanding of the importance of the various factors which affect vital capacity, such as diseases of the heart and lungs, general physical condition, body strength and weakness,¹⁰ and the effect of age, race, athletics, posture,¹¹ social environment, etc. All are necessary for a proper evaluation of results.

METHOD

In taking vital capacity measurements on Chinese during routine physical examination of students of the College of Yale in China and city schools, also of patients in the Hunan-Yale Hospital, it was found that the vital capacity of the Chinese fell considerably below the standards adopted for Americans. The following investigation was therefore undertaken to determine a normal standard for the Chinese, and incidentally, to study the effect of various occupations on the vital capacity.

The instrument used was a water spirometer of 6½ liters' capacity. This was copied by a local brass smith from a Narragansett Machine Company model owned by the local Y. M. C. A. Our machine was calibrated by the physics department of the premedical department, and, in operation, has checked accurately with the original.

The procedure in each case involved a careful explanation and demonstration of the method. Care was taken to see that the person took his deepest inspiration. Maximum efforts were stimulated by the competition which always developed when a number were being tested. Two to five attempts were recorded, and the highest taken as the vital capacity. Unsatisfactory cases were discarded. Routine physical examinations were not attempted, although men with gross defects

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were not accepted. All were doing their daily work and were in apparent good health. Weights were taken in pounds on the hospital balance scales and on a portable spring scale which had been checked with the balance type, and later changed to kilograms. Measurements were taken with clothing on. As the amount of clothing varies considerably in different classes of persons and in different seasons of the year, an average costume for each group was weighed and correction was made at the time of calculation. As some were barefoot, a correction was made for those wearing shoes. Body surface was determined from the height and weight by use of the DuBois¹² chart. Ratios to body surface and to height were calculated and the results tabulated.

RESULTS OF INVESTIGATION

Records of over 600 were obtained, representing many types, ages and occupations; of these, only 500, in ten groups, were taken for analysis. The results can be best appreciated by a brief discussion of each group.

Soldier Group.—In this group were ninety-seven soldiers, 18 to 40 years of age, from the Changsha military barracks. They probably represent the average soldier of the Hunan provincial troops. Records were taken after a daily drill. Deductions of 4 pounds (2 kg.) for weight of uniform and 1 cm. for height were made. The average for the group was 1.89 for surface and 18.8 for height ratio; the figures ranged from 2.57 to 1.34 and from 26.1 to 13, respectively.

Policeman Group.—This group included forty members of the Changsha civil police force and represents the average young adult male of Changsha engaged in a moderately active outdoor occupation. The same correction for uniform and shoes was made as for the soldiers. The averages here were slightly higher, being 2.09 for surface and 19.7 for height; the extremes ran from 2.82 to 1.45 for the former and from 27.4 to 13 for the latter.

Workman Group.—This group included forty-nine artisans from different trades, including carpenters, masons, painters, weavers, printers, shoe-makers and barbers. This is more of a social classification than a similar type of labor. Hours of work are long, from twelve to sixteen hours a day. The ages run from 17 to 40. Three pounds (1.4 kg.) were deducted for weight of clothes and 8 cm. for height of shoes. An average of 2.03 for surface and 19.5 for height was obtained, the upper and lower limits being 2.69 and 1.37 for surface ratio and 26.1 and 12.8 for height.

12. DuBois, D., and Dubois, E. F.: Clinical Calorimetry. Tenth paper. A formula to Estimate the Approximate Surface Area if Height and Weight be Known, Arch. Int. Med. **17**:863 (June) 1916.

Shop Clerks.—Forty men were obtained from one of the silk stores in the city. They represent a fairly well-to-do class in a sedentary occupation. Records were taken in the shop at the end of the day's work. Three pounds (1.4 kg.) were deducted for clothes and 1 cm. for shoes. These men are the smallest in size and have the lowest ratios of any group of men except the soldiers, being 1.90 liters per square meter of body surface and 17.6 c.c. per centimeter of height. The extremes were 2.39 and 1.13 for surface and 21.9 and 10.2 for height.

House Coolie Group.—Altogether, forty-nine subjects of this group were studied. They were the indoor coolies¹³ of the Hunan-Yale Hospital and Changsha Y. M. C. A. Their hours of work are long, but the work is not arduous, being mostly that of the janitor, housemaid, orderly, doorkeeper, watchman, or messenger type, etc. Four pounds (2 kg.) were deducted from the weight and 1 cm. from the height. Figures for this group were 2.12 surface ratio and 20.5 for height, the maximum being 2.68 and 25.5, the minimum 1.79 and 17.1, respectively.

Ricksha Coolie Group.—These men put in long hours pulling, generally on the run, the two wheeled passenger jinrickshas. This is the common method of travel in the large cities, and one would expect the coolies to develop extraordinary powers of endurance and wind, as the work is quite exhausting. In Changsha the rough streets do not permit great speed, so the work is a little harder than the ordinary coolie labor. Forty men were studied. The ages ranged from 20 to 50. All were barefoot; only 2 pounds (1 kg.) were subtracted for clothes. The average for this group was 2.01 for surface ratio and 19.3 for height, the upper and lower limits being 2.5 and 1.5 for surface, 23.5 and 14 for height. It is likely that in Shanghai, Hankow, Peking, or other better paved cities, the figures for this group would differ.

Carrying Coolie Group.—Forty of this type of laborer were obtained in two of the coolie guilds in the city. These men carry heavy burdens suspended from a pole which is carried on the shoulder. A large part of the freight in China is handled in this manner. It is heavy work and the men are noted for their endurance. They represent a group of strong and muscularly developed workers. They were barefoot; 2 pounds were deducted for clothes. The results for this group were 2.01 for surface and 19.7 for height ratios, the figures ranging from 2.54 to 1.65 and from 26.5 to 15.7, respectively.

Glassblowers' Group.—In this group also forty were studied. They were found in two glass factories in the city. This is a hard working group; blowing glass puts a great strain on the expiratory muscles, and one would expect an increase in lung capacity. They were barefoot;

13. "Coolie" is the Eastern term for the common laborer.

2 pounds were deducted from the weight. The surface ratio for this group was 2.13; for height, 20.3. The extremes were 2.52 and 1.5 for the former, 25.2 and 14 for the latter.

Students' Group.—There were thirty-six in this group, including medical students, hospital interns and a few male nurses. The ages ranged from 19 to 31. These represent a rather picked group of normal active young adults, although they are more athletic than the ordinary Chinese. A correction of 4 pounds was made for clothes and 1 cm. for shoes. The averages for this group were 2.18 surface and 21 height ratio; the figures ranged from 2.56 to 1.74 for the former and 25.6 to 16.4 for the latter.

Female Students.—In this group were seventy-five girls, from 16 to 22 years of age, from the Fu Siang Girls' School and from the Hunan-Yale School of Nursing. All had had physical examinations before these records were taken. The group represents the average well-developed Chinese young woman. The height and weight figures show what small bodies most of the girls have. No correction was made for clothing. The averages here were 1.54 for surface and 14.3 for height ratio, with the extremes of 2.08 and 0.99 for the former, 19.4 and 9.2 for the latter.

Foreigners' Group.—The records of twenty-five occidentals were obtained for comparison with the Chinese. In this group were included physicians of the hospital staff, teachers in the College of Yale in China, local business men and some sailors from the U. S. S. *Quiros*. The ages ranged from 19 to 48. No deductions were made for clothing, so the results are slightly lower than if measurements were taken stripped. The averages for the group were 2.39 liters per square meter of body surface and 25.1 c.c. per cubic millimeter of height. The extremes here were 2.87 and 1.64 for surface, with 31.8 and 18.9 for height ratios.

COMMENT

A study of the vital capacity of 425 men and seventy-five women in different groups of Chinese (Table 1) shows a general average of 2.02 liters per square meter of body surface for the men and 1.53 for the women. For convenience, the flat figures of 2 and 1.5 have been adopted as the normal standard for surface ratio for men and women, respectively. An analysis of the individual cases according to occupational groups (Table 2), shows only 42 per cent. of the men and 51 per cent. of the women within plus or minus 10 per cent. of the standard; about 20 per cent. of both men and women are below 90 per cent. Compared with the American standard of 2.5 for men and 2 for women, we find that 80 per cent. of the men and 85 per cent. of the women fall below 90 per cent. of the normal.

TABLE 1.—*A Comparison of the Vital Capacity Measurements of Eleven Occupational Groups of a Total of Five Hundred Chinese*

Group	No.	Average Vital Capacity, C.c.	Average Height, Cm.	Average Weight, Kg.	Average Body Surface, Liters per Sq. M.	Surface Ratio, Liters per Sq. M.	Height Ratio, C.c. per Cm.
Soldiers.....	97	3,070	164.0	58.0	1.63	1.89	18.8
Policemen.....	40	3,270	163.0	53.4	1.55	2.09	19.7
Workmen.....	49	3,160	162.0	54.0	1.55	2.03	19.5
Shop clerks.....	40	2,840	161.0	49.1	1.49	1.90	17.6
House coolies.....	43	3,320	161.0	54.8	1.56	2.12	20.5
Ricksha coolies.....	40	3,090	160.0	53.8	1.54	2.01	19.3
Carrying coolies.....	40	3,240	162.0	56.8	1.61	2.01	19.7
Glassblowers.....	40	3,280	162.0	52.3	1.54	2.13	20.3
Students.....	36	3,520	167.0	55.2	1.60	2.18	21.0
Average of.....	425	3,180	163.0	54.7	1.58	2.02	19.5
Women.....	75	2,240	157.0	47.7	1.45	1.54	14.3
Foreigners.....	25	4,360	174.0	69.6	1.83	2.39	25.1

TABLE 2.—*Percentage Relation of Surface Ratios to Standards*

Group	No.	Average Surface Ratio, Liters per Sq. M.	% Local Standard, 2 Liters per Sq. M.	Above 110 per Cent.		Below 90 per Cent.		Below 80 per Cent.		% West's Standard, 2.5 Liters per Sq. M.	Below 90 per Cent.	
				No.	Per Cent.	No.	Per Cent.	No.	Per Cent.		No.	Per Cent.
Soldiers.....	97	1.89	95	7	7	31	32	15	15	75	94	97
Policemen.....	40	2.09	105	16	40	8	20	2	5	84	28	70
Workmen.....	49	2.03	102	9	18	8	16	1	2	81	44	90
Clerks.....	40	1.90	95	8	20	12	30	6	15	76	33	82
House coolies.....	43	2.12	106	15	35	1	2	..	..	85	31	72
Ricksha coolies.....	40	2.01	100	12	30	9	22	4	10	80	30	75
Carrying coolies.....	40	2.01	100	11	28	10	25	..	..	80	30	75
Glassblowers.....	40	2.13	107	16	40	2	5	2	5	85	28	70
Students.....	36	2.18	109	17	47	2	6	..	..	87	22	61
Average of.....	425	2.02	101	111	26	83	19	30	7	81	340	80
Foreigners.....	25	2.39	119	20	80	1	4	..	..	96	7	28
Women.....	75	1.54	Local Standard, 1.5 Liters per Sq. M.	22	29	15	20	3	4	West's Standard, 2 Liters per Sq. M.	64	85

TABLE 3.—*Percentage Relation of Height Ratios to Standards*

Group	No.	Average Height Ratio, C.c. per Cm.	% Local Standard, 19 per Cm.	Above 110 per Cent.		Below 90 per Cent.		Below 80 per Cent.		% West's Standard, 20 per Cm.	Below 90 per Cent.	
				No.	Per Cent.	No.	Per Cent.	No.	Per Cent.		No.	Per Cent.
Soldiers.....	97	18.8	99	17	18	25	26	11	11	75	92	95
Policemen.....	40	19.7	104	20	50	10	25	2	5	79	35	87
Workmen.....	49	19.5	103	15	30	8	16	1	2	78	47	96
Clerks.....	40	17.6	90	7	17	17	42	9	22	70	40	100
House coolies.....	43	20.5	108	17	39	..	..	..	..	80	35	81
Ricksha coolies.....	40	19.3	101	12	30	9	22	3	7	77	36	90
Carrying coolies.....	40	19.7	104	12	30	7	17	..	..	78	34	85
Glassblowers.....	40	20.3	107	15	38	4	10	2	5	81	31	78
Students.....	36	21.0	111	19	53	3	8	..	..	84	24	67
Average of.....	425	19.5	102	134	31	83	19	28	7	78	374	88
Foreigners.....	25	25.1	132	21	84	..	..	..	..	100	6	24
Women.....	75	14.3	Local Standard, 14 C.c. per Cm.	22	29	17	23	5	7	West's Standard, 20 C.c. per Cm.	70	93

Height ratios show an average of 19.5 c.c. per centimeter of body height for men and 14.3 for women. The flat figures of 19 and 14 were taken as the normal standard. A study of the individual and group variations (Table 3) shows a general similarity to the body surface ratios; only 50 per cent. of the men and 48 per cent. of the women are within 10 per cent. of standard, with approximately the same proportion as above falling below 90 per cent. The height ratios seem to show a wider range, yet, on the whole, follow the surface ratios closely. Compare these results with the Western standards of 25 c.c. per centimeter of height for men and 20 for women, and we find that only fifty-one men and five women are within 90 per cent. of those figures, that is, 88 per cent. of the men and 93 per cent. of the women are below 90 per cent.

A comparison of the averages of the occupational groups shows some differences which seem to be greater than the normal error. The soldiers have the lowest vital capacity with an average surface ratio of 0.13 below the general average, while the students are the highest with 0.16 above. The reason for the low figures for this group of soldiers is not apparent, although one is tempted to question their physical fitness. The shop clerks, with little physical work, have a low lung capacity, almost as low as that of the soldiers. The coolies of different types have about the same ratios. It is surprising that the ricksha coolies have not a higher vital capacity, their capacity being lower than that of the house coolies whose work is chiefly indoors. The glass blowers, as expected, have the highest capacity of all the laborers, although theirs is lower than that of the students. The students, on the whole, had been fairly active in sports, basket ball and soccer football, and it would seem as though athletics were the important factor in this case. This seems to confirm the doubt raised by Hewlett and Jackson that standards based on a picked group, such as college students, are too high for the general public.

The average for women is much lower than for men. This is in keeping with the difference noted by West, and the proportion is approximately the same. It is interesting to note that the figures for women are lower than those obtained for schoolchildren from 6 to 16 years of age in New York City.

The group of foreigners gives an average surface ratio of vital capacity of 2.39. This is low as compared with West's standard; seven of the twenty-five being below 90 per cent. The height ratio of 25.1 for the group equals the standard for Americans. The group, as a whole, which includes several overweight and quite sedentary persons, is more than 15 per cent. greater in both surface and height ratios than the Chinese. As the measurements were taken under the same conditions, a racial factor is strongly suggested. No vital capacity studies on

other Eastern races have been found for comparison. It has been noted, however, that the figures for negro children in the United States are less than for the white children of the same ages.⁵

In this study, the height ratios give nearly as uniform results, although there is more variation in the extremes. This method is simpler, and for rapid calculation in clinical work is probably preferable.

Figures obtained for Chinese in Central China will not necessarily hold true for the whole country, since there is a great difference in the stature and physical development of the different races of the Chinese.

SUMMARY

1. The vital capacity in 500 Chinese in eleven occupational groups, including a number of young women, has been studied and analyzed.
2. A normal standard of 2 liters per square meter of body surface for men and 1.5 for women was obtained.

TABLE 4.—*Summary of Normal Standards*

	Vital Capacity Body Surface, Liters per Square Meter	Vital Capacity Height, C.c. per Centimeter
Americans:		
Men ⁴	2.5	25.0
Women ⁴	2.0	20.0
Children ⁵	1.93	15.5
"Athletes" ⁴	2.8	29.0
Chinese:		
Men.....	2.0	19.0
Women.....	1.5	14.0

3. A normal standard of 19 c.c. per centimeter of body height for men and 14 for women may also be used with little less accuracy.

4. Various factors were noted which affect the vital capacity: (a) Men show a vital capacity 31 per cent. greater than women. (b) Occupations seem to influence the vital capacity to some extent, although not in proportion to the degree of physical activity. (c) Athletics tend to increase the vital capacity.

CONCLUSIONS

The Chinese show much lower vital capacity ratios than Westerners. Standards based on a picked group of persons cannot be applied uniformly to all groups.

