CONTRIBUTION
TO THE
STUDY OF SPIROMETRY.

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A PAPER "On the Capacity of the Lungs, and on the Respiratory Functions," was read before this Society, in 1846, by Mr. John Hutchinson, in which he gave the results of an extensive series of observations, made with great care, by means of instruments invented by himself which ensured a degree of accuracy in measurement not attained previously. The results were highly interesting, and the paper, which was published in the twenty-ninth volume of the 'Transactions' of the Society, is entitled to rank as a valuable addition to our knowledge on this branch of physiological science. Further observation and experiment, however, appeared necessary to determine the utility of the spirometer for some of those practical purposes to which Mr. Hutchinson deemed it applicable.

Shortly after the publication of the paper, the medical officers of the Grenadier Guards procured one of his spirometers, with a view to test its value in the examination of recruits, and to ascertain, if possible, whether any relation exists between the capacity of the lungs, as measured by it, and the tendency to pulmonary disease, as shown in the

subsequent medical history of the soldier. For this purpose the height and "vital capacity," as it was termed by Mr. Hutchinson—or the number of cubic inches given by a full expiration following the deepest inspiration—of all the recruits examined at the head-quarters of the regiment were carefully measured and recorded in the recruit-book. Through the kindness of my friend, Mr. George Brown, late Surgeon-Major of the Grenadier Guards, I had access to all the hospital books and records, and was enabled to tabulate the results of these measurements, and to trace the medical history of each recruit enlisted between October, 1848, and March, 1853, from the period of his joining the regiment up to the date of the embarkation of the Guards for the East, in March, 1854. The disturbing influences which then came into operation, were so great as to prevent any accurate deduction being drawn from the subsequent history of the men.

The number of recruits taken on the strength of the regiment during this time, exclusive of a few boys and transfers from other corps, was 1126; the time which elapsed between the date of enlistment of the first man on the list, and that to which the medical histories were traced, was six years and a half; and between the examination of the last man and the same date, was twelve months; taking the average service of the whole of the men, it amounted to three years and five months.

It would have been desirable to have had a larger number of men under observation, and for a longer period; but as many years must elapse before such data can be obtained, I venture to submit this paper as a contribution to the study of spirometry, claiming for it no further credit than that the observations have been accurately recorded, the subsequent history of the men carefully traced, and the results honestly and impartially brought out.

Before entering upon the question of the tendency to pulmonary disease, it may be necessary to examine how far the general results as to "vital capacity" obtained by the medical officers of the Guards, correspond with those of Mr.

Hutchinson. This is accordingly shown in the following table :

Height.	GUARDS.		HUTCHINSON.		
	Number of observations.	Mean vital capacity.	Number of observations.	Mean vital capacity.	Capacity calculated in arithmetical progression.
5 feet 7 to 5 feet 8...	17	225.53	411	228	230
5 " 8 to 5 " 9...	315	237.51	329	237	238
5 " 9 to 5 " 10...	400	242.04	201	246	246
5 " 10 to 5 " 11...	235	249.16	116	247	254
5 " 11 to 6 feet.....	113	253.75	112	259	262
6 feet and upwards...	46	264.00	80	276	270

The vital capacity of men six feet and upwards, as shown in the two series of observations, differs widely ; but the comparison is wanting in accuracy, as there is no evidence to show that the proportion greatly exceeding six feet is nearly the same in each series. Indeed, Mr. Hutchinson incidentally mentions two cases in which the height exceeded six feet eleven inches, while none of the Guards at all approached that height, and two such cases in so small a number as eighty observations would of themselves materially affect the results. This opinion is corroborated by the fact that sixty-two observations made by Mr. Hutchinson on seamen, Horse and Foot Guards, and police, gave an average of only 260. As regards the men under six feet, there is a source of difference in the two series, arising from the mode of tabulating the observations ; but the extent to which it affects the results can be accurately determined. In Mr. Hutchinson's tables the height has been taken as up to and including the complete inch ; while in those of the Guards it has been taken, according to the more usual practice, from the inch inclusive. By the former the height from five feet eight inches to five feet nine inches, does not include the men of five feet eight inches, but those of five feet nine inches ; whereas, in the other tables, it comprises men of five feet eight inches, and up to, but not inclusive

of, five feet nine inches. As the increment of height is usually taken in eighths of an inch ; and as, according to Mr. Hutchinson's observations, the "vital capacity" increases eight cubic inches with every inch of height ; this difference in the mode of making the observation would give rise to a difference of one cubic inch of capacity at each height.

It must be obvious that the "vital capacity" stated in the preceding table is the average of men of five feet seven and a half, eight and a half, nine and a half inches, &c. ; but if the observations for every two inches of height be combined, and the mean taken, the result will be the average for the exact height of five feet eight, nine, and ten inches, &c. This has been accordingly done in the following table ; and at the same time the correction above noted has been made in Mr. Hutchinson's observations.

Average of men of	5 feet 8.	5 feet 9.	5 feet 10.	5 feet 11.	6 feet.
Guards . .	231·5	239·8	245·6	251·5	258·9
Hutchinson . .	231·5	240·5	245·5	252·0	258·5

The identity of the results in the two series of observations, after the necessary corrections have been made to bring them into strict comparison, is very remarkable, and may fairly be deemed an evidence of their accuracy.

Having thus shown that the men under observation had a fair average "vital capacity," we shall proceed to examine the question how far a capacity under the average may be taken as an indication, either of a tendency to pulmonary disease, or of a feeble constitution rendering the man liable to a higher rate of mortality than that to which men of, or above, the average are subject. With a view to test this, the men were divided into three classes :—

1st. Those whose "vital capacity" was more than ten inches under the average calculated for men of the same height by Mr. Hutchinson's tables.

2d. Those whose capacity ranged between ten cubic inches under, and ten above, the average.

3d. Those whose "vital capacity" exceeded the average by more than ten inches.

In the first class there were 416, in the second 342, and in the third 368 men. The average service of the first class, up to the 31st of March, 1854, was 3·632 years, of the second, 3·348, and of the third, 3·277. From these data we find the strength of the first class to have been equal to 1511, of the second to 1145, and of third to 1206 men, under observation for one complete year. The following table shows the number of deaths which occurred in each of these classes.

	Under the average.	Average.	Above the average.	Total.
Strength	1511	1145	1206	3862
Deaths	31	23	24	78
Ratio of deaths per 1000 of strength }	20·52	20·09	19·90	20·20

This table shows a remarkable coincidence in the mortality of the three classes, the difference amounting only to 0·6 per 1000 of the strength, in favour of the highest "vital capacity."

But, in addition to the loss to the service by death, forty men were discharged as invalids, and they belonged to the three classes as follows : first class, twenty-seven ; second, seven ; and third class, six ; so that the number who became non-effective was much greater in the men having a "vital capacity" below the average than in the other two classes, though the deaths so nearly approximated.

It was supposed that the spirometer would be valuable in the selection of recruits, by indicating those men in whom a tendency existed to pulmonary disease. In testing the accuracy of this opinion, it must be borne in mind that consumption is one of those diseases in which, from their slow

progress, it is easy, and with a view to military efficiency, even necessary to remove the men from the ranks by invaliding. The proportion so discharged, therefore, must be taken into account along with the deaths in estimating the amount of these diseases in each class of Recruits. The results are shown in the following table :

	Aggregate Strength.	By Consumption.			Ratio per 1000 of strength.		
		Died.	Invalided.	Total.	Died.	Invalided.	Total.
Below the average	1511	19	17	26	12·57	11·25	23·82
Average	1145	14	3	17	12·23	2·62	14·85
Above the average	1206	17	3	20	14·09	2·49	16·58

This table shows the loss to the service, by consumption, to have been much greater among the men having a "*vital capacity*" below the average than in the other two classes. The proportion of deaths does not differ materially in the three classes, but the invaliding has been four times as high among the men under the average as among the others. The deaths among the men above the average are rather higher than among those of the average class, but the difference is so small as probably to be attributable to irregularity arising from limited data.

These results appear scarcely to justify the conclusion that a definitive relation exists between the "*vital capacity*" and the tendency to pulmonary consumption. Had this been the case, the proportion attacked should have been found to decrease among the men above the average.

The legitimate deduction from them seems to be that a "*vital capacity*" below the average may be considered as indicating a generally feeble organization, less capable of resisting the deteriorating influences to which a soldier is exposed. This conclusion would justify Mr. Hutchinson's opinion that the spirometer might be advantageously employed in judging of the fitness of recruits for the army.

But unfortunately there is a practical difficulty in its application which appears to be insurmountable. If all men under a given "vital capacity" were to be refused, it would be easy for an unwilling recruit to ensure his rejection, as no means exists of testing whether he really inspires and expires to the full extent of his power. The spirometer, however, might be useful as an indication to the Inspecting Officer of the necessity for a careful examination by the stethoscope, to ascertain the actual condition of the lungs and heart, where a very low capacity was shown.

The views expressed by Mr. Hutchinson, of the practical value of his instrument to the Medical Referees of Life Assurance Companies appear to be confirmed by these observations. As there is no inducement for the persons wishing to effect an assurance to mislead, at least in the direction of want of capacity, medical referees would be extremely cautious in recommending the acceptance of any person whose vital capacity was much below the average; and would probably advise the proposal to be declined, if there were any flaw in the personal or family history, and unless the results of a careful examination of the chest by percussion and auscultation were in the highest degree satisfactory.