STUDIES IN THE VITAL CAPACITY OF NOKTE NAGAS OF TIRAP FRONTIER DIVISION (NORTH-EASTERN FRONTIER)

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INTRODUCTION

Hutchinson (1848, quoted by Myers, 1925) concluded after extensive investigations that the variations in the measurements of vital capacity of healthy individuals could be only due to the variations in the physical builds of the persons. Dreyer (1919) pointed out that the variation in the vital capacity might be due to racial factor. He also devised formulae to correlate vital capacity with standing height, sitting height, weight, chest circumference, etc. He argued that the sitting height was a better index of vital capacity than the other measurements. West (1920) found best correlation between vital capacity and body surface area as calculated from Du Bois's formula and suggested that the ratios of $\frac{\text{vital capacity}}{\text{standing height}}$ and $\frac{\text{vital capacity}}{\text{surface area}}$ should be used as normal standards. Attempts were also made to correlate vital capacity with trunk measurements (Jackson and Lees, 1929). Wilson and Edwards (1921) supported the theory of racial factor after getting strikingly low results in the coloured children. Similarly, Foster and Hsieh (1923) obtained much lower values both in the Chinese males and females as compared with the American males and females.

Whatever the causative factor or factors of variations may be it is always true that the vital capacity of lungs is a test for determining the physical fitness and efficiency since this is measured by a maximum expiratory effort after a maximum inspiration by the lungs. Its variation in different subjects from the standards of one race who are living under the identical climatic and other conditions is taken to be due to poor physique or unhealthy with diseases, particularly those of the respiratory system.

Undoubtedly, therefore, the vital capacity test is of great physiological importance and it is also a valuable guide in the medical diagnosis of diseases of heart and lungs. In Great World War I, this test was used in the U.S.A. for assessing the physical fitness and efficiency of individuals for the purpose of recruitment to various military services. It was also one of the tests used for recruitment to the Royal Air Force.

For determining the vital capacity standards for normal individuals of different countries, correlations had been worked out between vital capacity on one hand and different physical measurements on the other. Statistical methods were also used by some workers. Hutchinson (*loc. cit.*) initiated the work in England and thereafter the problem was extensively worked out in England and U.S.A. Foster and Hsieh (*loc. cit.*) and McCloy (1927) worked on the Chinese, Satake and Sato (1938, quoted by Telang and Bhagwat, 1941) determined the vital capacity of the Japanese and Myers (*loc. cit.*) worked on the Philippinos. A brief description of the studies carried out in India is given below for comparative study.

Vital capacity of Indians

To determine the Indian standards vital capacity tests were mainly made on the medical students of Bombay, Madras and Bengal. Bhatia (1929) observed a racial difference in Bombay after getting much lower results there. Krishnan and Vareed (1932) working on 103 male South Indian students observed the average of 2·86 litres or only 67 per cent of the average British and American standards. The authors put forward the arguments that the lower standards obtained were not due to racial differences but due to influence of hot climate resulting in low metabolism and less tendency to work. The same authors (1933) repeating the estimations on 260 medical students obtained the average vital capacity of 3·05 litres or 75 per cent of the American standards. Mason (1932) found that the average vital capacity in 587 South Indian women subjects was 2·15 litres which was 76 per cent of the average standard of American women. She suggested series of anthropological measurements and study of the weight of the lungs to find out how much of the differences was due to racial factor. Chatterjee (1933) worked out the average vital capacity of Bengali College students at the age of 19 years along with other physical measurements and he found the normal value of 2·72 litres, statistical data and correlation ratios with other physical measurements were not worked out. Calcutta University (1934) reported that the average vital capacity of 522 Bengali College students between the ages of 17 to 20 years was 3·0 litres, the coefficient of variation of vital capacity was between 16–22% and the variability of the direct ratio between vital capacity and body surface area was minimum. There is a big difference in these two results of Bengali College students, investigations for both of which were carried out under the auspices of Calcutta University and at about the same time. De and De (1939) observed the average vital capacity of Bengalees was only 2·721 litres which was lower than the results obtained in Bombay and Madras but same with the finding of Chatterjee (*loc. cit.*). Telang and Bhagwat (1941) with the main object of investigating the correlation between the vital capacity and other physical measurements by statistical methods estimated the vital capacity of 172 Bombay medical students. The average was 2·95 litres. Standing height and sitting height were found to be least variables, weight was more so than the surface area. Vital capacity was found to be least correlated with age and pelidisi but significantly correlated with other measurements to a greater or lesser degree. Reddy (1933) recorded observations on 105 male students of Vizagapatam. Reddy and Sastry (1944) repeated estimations in 310 individuals of which 213 were students. They respectively obtained the averages of 3·156 and 2·985 litres. They got best correlation between vital capacity and sitting height. Lundgren, Sen Gupta and Saha (1953) studying the lung volumes and maximal breathing capacity among Indian men with sedentary occupations obtained the average of 3·57 litres and it was 6 per cent smaller in recumbent than in standing body position. No difference was found by them in comparisons of the vital capacity during the comfortable winter season and the hot pre-monsoon season. It is evident from the above results and on the basis of the existing data that no conclusion of a racial factor can be drawn.

The vital capacity estimations were mainly carried out among the students of Bombay, Madras and Bengal and were not made in other important States and in different categories of working classes. Correlations which were worked out by different authors were also not uniform.

The aboriginal tribes of India are generally living in the hills, in the frontiers and in some isolated areas. They have generally well built bodies, possess unlimited energy and can do quite a heavy manual work. At the same time, all the tribes are not of the same physical capacity, the nutritional quality of their dietaries vary considerably and the rates of growth of their children differ strikingly. Vital

capacity test has not been hitherto made on the tribes and such studies will in one way express their comparative physical fitness.

The studies on the vital capacity of Nokte Nagas is a part of the research programme of the Department of Anthropology on the diet, nutrition, health, physical fitness, nutritional deficiencies, nutritional status and growth of children, vital capacity, basal metabolism and other dietary and nutritional problems of the tribes of India and to these investigations the author is entrusted.

The Nokte Nagas

Besides the more advanced Nagas living in the Naga hills district within Assam State different sections of Nagas dwell in the two frontier districts of Tirap Frontier Division and Tuensang Frontier Division in N.E.F.A. Culturally, socially and linguistically all these sections of Nagas are quite different. The Nokte Nagas are the inhabitants of one sub-division of Tirap Frontier Division just on the border of north-western Burma, inhabited mostly by the unadministered tribes. These Nagas were once dangerous and well known for their head-hunting but now they are law-abiding people and extended full co-operation to the investigating party under the leadership of the author. These tribes were not found to be as strong and as vigorous as those of the Padam, Minyong and Galong tribes of Abor hills where the author had the opportunity to work for many years. Anthropological investigations were carried out among the Nokte Nagas during the period from March to June, 1954.

Investigational procedures

Subjects.—The subjects were all healthy male adults between approximately 18 to 45 years age.

General.—The observations on the vital capacities of Nokte Nagas were made between March to June, 1954. The climate was very moist as it was raining heavily during the period. The estimations were made either in the morning between 9 to 11 and in the afternoon between 3 to 4-30. The investigation will be continued among other tribes for a comparative study.

Age.—All the subjects were adults. Approximate ages were recorded but correct ages could not be ascertained since they did not know counting and could not state real age. Therefore no correlation has been attempted in this paper between age and other physical measurements or vital capacity.

Standing height.—This was measured on a wooden platform with anthropometer graduated in millimetres.

Sitting height (stem length).—This was measured by seating the subject on a wooden chair and measuring the stem height with the anthropometer.

Weight.—The weight was recorded in pounds to the nearest half pounds and then the results were converted to kilos.

Pelidisi.—Various indices were suggested on the basis of anthropological measurements, mainly height, sitting height and weight, to determine the nutritional state. Pelidisi, originated by von Pirquet (1922, quoted by Mason, 1931), was calculated from the formula :—

$$\sqrt[3]{\frac{10 \times \text{weight (g.)}}{\text{sitting height (cm.)}}} \times 100$$

and gave ideal values of 100 for small children and 97-98 for the adults and the values below 90 and above 110 denoted respectively undernutrition and obesity. The index fitted well in the western countries for a considerable period but the Indian workers did not find correlation with vital capacity. Calculations have been

made in this paper to determine if pelidisi of Nokte Nagas is correlated with their vital capacities.

Vital capacity.—For this determination, a wet type chain compensated spirometer calibrated in c.c., having a hollow light metalled cylinder, supplied by Messrs. C. F. Palmer Ltd., London, was used. The subject was instructed to take maximum inhalation in standing position and expel out the air in the cylinder through a metallic mouthpiece and rubber tube connection with the spirometer with maximum possible effort. The maximum value of the three efforts was recorded in each case.

Statistical methods.—The results obtained by the above procedures have been tabulated and the means, standard deviations and coefficients of variation have been worked out for each measurement. Correlation coefficients have also been computed between vital capacity and each of the other measurements. This is to determine whether the relationship between vital capacity and each of the other measurements is significant and whether this relationship is linear.

Results

The actual data obtained on 140 subjects are recorded in Tables I, II, III, IV and V. In these Tables correlation between vital capacity and height, sitting height, weight, body surface area and pelidisi have been shown. At the bottom of each Table vital capacity corresponding to each range of each measurement and vital capacity per sq. m. of surface area have also been incorporated. The ranges of measurements, the mean values, standard deviations and coefficients of variation are given in Table VI. The correlation coefficients and the vital capacity per unit of each measurement are shown in Table VII. A comparative study of the vital capacity in Indians, non-Indians and of the Nokte Nagas has been made in Table VIII. In figures 1 to 5 are shown the correlation between vital capacity and standing height, approximate age, sitting height, weight, body surface area and pelidisi. The age range of the subjects represents the physically fit and able bodied persons. The mean vital capacity in the subjects was 3,035 c.c. or 2,004 c.c. per sq. m. surface area.

Table I

Correlation between vital capacity and height, in Nokte Nagas

Vital capacity (in litres)	Height in cm.							
	Total	140–144	145–149	150–154	155–159	160–164	165–169	170–175
Total subjects	140	2	11	27	52	35	11	2
1·6 –1·9	2	..	1	1	..	..	..	..
1·91–2·2	4	..	1	3	..	..	..	..
2·21–2·5	12	1	2	3	4	1	1	..
2·51–2·8	24	1	3	6	8	5	1	..
2·81–3·1	45	..	4	10	20	9	1	1
3·11–3·4	29	..	..	3	13	10	3	..
3·41–3·7	15	..	..	..	5	7	3	..
3·71–4·0	7	..	..	..	2	3	1	1
4·01–4·2	2	..	..	1	..	..	1	..
Average vital capacity (in litres) ..		2·45	2·55	2·79	3·06	3·23	3·39	3·45
Vital capacity per sq. m. (in litres)		1·89	1·85	1·93	2·01	2·05	2·04	1·94

TABLE II

Correlation between vital capacity and sitting height in Nokte Nagas

Vital capacity (in litres)	Sitting height in cm.									
	Total	73–75	76–78	78–79	80–81	82–83	84–85	86–87	88–89	90–92
Total subjects ..	140	3	3	24	28	32	22	14	9	5
1·6 –1·9 ..	2	..	..	2	..	..	..	..	..	..
1·91–2·2 ..	4	..	..	2	1	1	..	..	..	..
2·21–2·5 ..	12	..	1	5	2	2	1	1	..	..
2·51–2·8 ..	24	2	..	5	5	5	5	2	..	..
2·81–3·1 ..	45	1	..	5	11	9	8	6	3	2
3·11–3·4 ..	29	..	1	2	6	8	6	2	3	1
3·41–3·7 ..	15	..	1	1	3	5	1	2	2	..
3·71–4·0 ..	7	..	..	1	..	2	1	1	1	1
4·01–4·2 ..	2	..	..	1	..	..	..	..	..	1
Average vital capacity (in litres) ..		2·77	2·93	2·79	2·94	3·08	3·07	3·18	3·27	3·48
Vital capacity per sq. m. (in litres) ..		2·07	2·13	1·93	1·86	2·00	2·01	2·06	2·00	2·08

TABLE III

Correlation between vital capacity and weight in Nokte Nagas

Vital capacity (in litres)	Weight in kilos						
	Total	40·0–44·4	44·5–49·4	49·5–54·4	54·5–59·4	59·5–64·4	64·5–70·0
Total subjects ..	140	8	20	59	39	9	5
1·6 –1·9	2	2	..	..	..	..	..
1·91–2·2	4	..	3	1	..	..	..
2·21–2·5	12	1	2	9	..	..	..
2·51–2·8	24	4	4	5	10	1	..
2·81–3·1	45	1	6	24	13	..	1
3·11–3·4	29	..	5	10	9	4	1
3·41–3·7	15	..	..	8	4	2	1
3·71–4·0	7	..	..	1	2	2	2
4·01–4·2	2	..	..	1	1	..	..
Average vital capacity (in litres)		2·47	2·78	2·98	3·17	3·38	3·59
Vital capacity per sq. m.		1·88	1·97	1·99	2·02	2·05	2·05

TABLE IV

Correlation between vital capacity and body surface area in Nokte Nagas

Vital capacity (in litres)	Body surface area in sq. m.									
	Total	1·3–1·34	1·35–1·39	1·4–1·44	1·45–1·49	1·5–1·54	1·55–1·59	1·6–1·64	1·65–1·69	1·7–1·75
Total subjects ..	140	9	4	19	21	38	26	14	2	7
1·6 –1·9 ..	2	1	1	..	..	..	..	..	..	..
1·91–2·2 ..	4	2	..	2	..	..	..	..	..	..
2·21–2·5 ..	12	1	..	4	2	3	1	1	..	..
2·51–2·8 ..	24	4	1	3	3	7	5	1	..	..
2·81–3·1 ..	45	1	1	8	11	12	8	2	1	1
3·11–3·4 ..	29	..	1	2	3	8	7	7	..	1
3·41–3·7 ..	15	..	..	..	1	7	2	3	..	2
3·71–4·0 ..	7	..	..	..	..	1	3	..	..	3
4·01–4·2 ..	2	..	..	..	1	..	..	..	1	..
Average vital capacity (in litres) ..		2·44	2·62	2·71	3·09	3·1	3·14	3·18	3·55	3·61
Vital capacity per sq. m. (in litres) ..		1·85	2·00	1·70	2·02	2·03	2·08	1·96	2·19	2·01

TABLE V

Correlation between vital capacity and pelidisi in Nokte Nagas

Vital capacity (in litres)	Pelidisi									
	Total	83–86	87–89	90–92	93–95	96–98	99–101	102–104	105–107	108–110
Total subjects ..	140	1	3	11	24	45	35	9	10	2
1·6 –1·9 ..	2	..	..	..	1	1	..	..	..	..
1·91–2·2 ..	4	..	..	..	1	2	1	..	..	..
2·21–2·5 ..	12	..	..	1	2	4	4	..	1	..
2·51–2·8 ..	24	..	..	2	6	5	5	3	3	..
2·81–3·1 ..	45	1	1	5	8	12	13	3	2	1
3·11–3·4 ..	29	..	2	2	2	13	7	2	1	..
3·41–3·7 ..	15	..	..	..	4	5	3	1	1	1
3·71–4·0 ..	7	..	..	..	..	3	2	..	2	..
4·01–4·2 ..	2	..	..	1	..	..	..	1	..	..
Average vital capacity (in litres) ..		3·10	3·25	3·07	2·92	3·04	3·00	3·14	3·11	3·70
Vital capacity per sq. m. (in litres) ..		1·98	2·17	2·04	1·97	1·99	2·03	2·06	2·01	2·14

TABLE VI

Statistical distribution of data

Number of subjects : 140. Sex : Male

Measurement	Range	Mean	Standard deviation	Coefficient of variation per cent
Age in years	16 – 45	30·4	7·28	23·95
Standing height, cm. ..	142·5 –170·7	157·38	5·38	3·42
Sitting height, cm. ..	72·6 – 99·1	82·59	3·74	4·53
Weight, kg.	41·6 – 66·4	53·72	5·37	10·00
Surface area (Du Bois), sq. m.	1·28– 1·81	1·514	0·031	2·05
Pelidisi (von Pirquet index)	83·2 –109·9	98·3	4·25	4·52
Vital capacity, litres ..	2·14– 4·21	3·035	0·4612	15·19

TABLE VII

Statistical correlation of vital capacity and other measurements

Correlation data	Correlation coefficient	Vital capacity per unit (in litres)
Vital capacity and—		
Standing height ..	0·702	0·0195 per cm.
Sitting height ..	0·606	0·036 per cm.
Weight	0·68	0·056 per kilo.
Surface area (Du Bois) ..	0·571	2·004 per sq. m.
Pelidisi	0·524	....

TABLE VIII *

Comparative vital capacity figures for Nokte Nagas, Indians and non-Indians

Country and worker	Age (years)	Vital capacity (litres)	Vital capacity (litres) / Standing height cm.	Vital capacity (litres) / Surface area (Du Bois) sq. m.
India—				
Bhatia (1929)	20–45	3·096	0·0185	1·96 (Bombay)
Mukherjee and Gupta (1930) ..	20–29	3·56	0·0212	2·253 (Bengal)
Krishnan and Vareed (1932) ..	18–29	2·929	0·0175	1·85 (Madras)
Idem (1933)	17–26	3·05	0·0185	1·93 (Madras)
Chatterjee (1933)	19	2·72	..	.. (Bengal)
Calcutta University (1934) ..	17–20	3·0	0·0182	1·91 (Bengal)
De and De (1939) ..	17–23	2·721	0·0165	1·79 (Bengal)
Niyogi and Patwardhan (1939)	18–36	2·552	0·0154	1·636 (Bombay)
Telang and Bhagwat (1941) ..	18–29	2·949	0·0176	1·83 (Bombay)
Reddy (1933)	..	3·156	0·0191	1·95 (Vizagapatam)
Reddy and Sastry (1944) ..	17–43	2·985	0·0179	1·911 (Vizagapatam)
Indian average—				
Men (from above data) ..	17–43	2·974	0·018	1·901
Women (Mason, 1932) ..	16–35	2·150	..	.. (Madras)
Nokte Nagas—				
(Sen Gupta, present paper) ..	16–45	3·035	0·0195	2·004 (T.F.D.)
Chinese (Foster, Hsieh, 1923) ..	Adults	3·18	0·0195	2·02
Japanese (Satake, Sato, 1938) ..	19–26	3·8	0·023	2·38
English (Average)	..	4·342	0·0249	2·42
American (Average)	..	4·547	0·0262	2·54

* In preparing this table help has been taken from Reddy and Sastry (*loc. cit.*) and Telang and Bhagwat (*loc. cit.*).

DISCUSSION AND CONCLUSION

The age range of the subjects is large covering almost all the able bodied persons engaged in manual labour. Ages shown in this paper are approximate as no definite information could be obtained from the tribe in this regard. Excepting graphical correlation (Figure 1) and statistical treatment in Table VI, no other consideration has been given to age in this paper.

In Table I and Figure 2 are shown the relationship between vital capacity and standing height. This relationship is linear. 114 (or 81·4%) of the subjects are of stature between 150 and 164 cm. and have a vital capacity of 2·79 to 3·23 litres (or 1·93 to 2·05 litres per sq. m. of body surface area). The average stature of the tribe is 157·38 cm. and the vital capacity per cm. of standing height is 0·0195 litre.

Sitting height is not correlated with the vital capacity so significantly as that of the standing height and weight. It is evident from Table II that 120 or 87·7% of the subjects have sitting height between 78 to 87 cm. and vital capacity of 2·79 to 3·18 litres. It will be seen from Figure 3 that the vital capacity more or less is in one level between 73 to 81 cm. and shows a gradual rise above that height up to 91 cm. For this reason this measurement of Nokte Nagas has no significant value in relation to vital capacity. Similar observation was also recorded by Krishnan

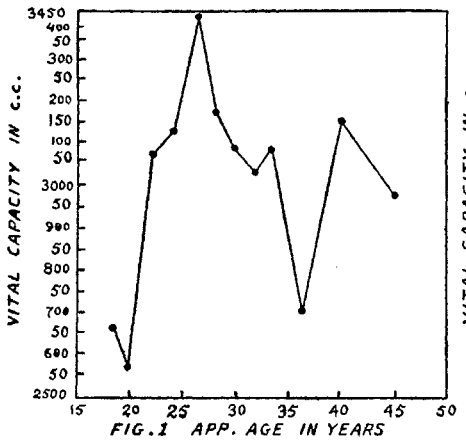

FIG. 1 APP. AGE IN YEARS

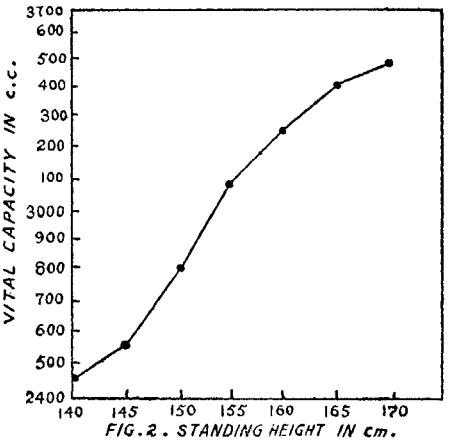

FIG. 2. STANDING HEIGHT IN cm.

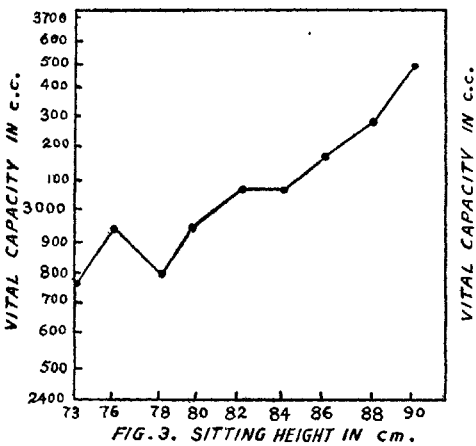

FIG. 3. SITTING HEIGHT IN cm.

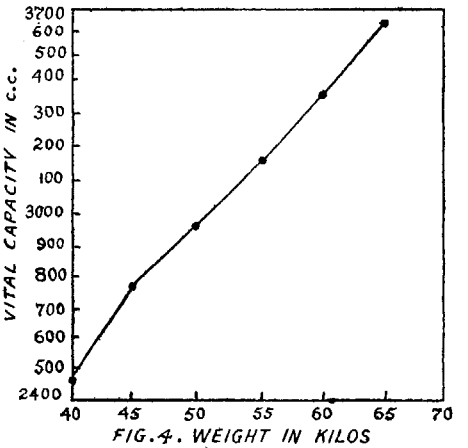

FIG. 4. WEIGHT IN KILOS

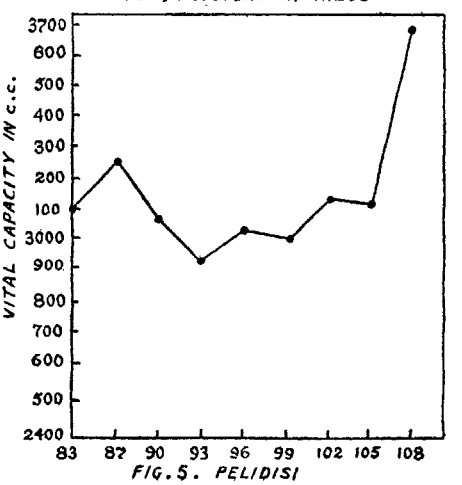

FIG. 5. PELIDISI

and Vareed (*loc. cit.*) in Vizagapatam. Telang and Bhagwat (*loc. cit.*) obtained more uniform curve. It is more variable than the standing height but much less so than those of weight and vital capacity.

A satisfactory correlation between weight in kilos and vital capacity exists and it is as significant as that between vital capacity and standing height. The linear relationship is evident from Figure 4. Table III shows that 118 or 84·3% of the subjects are of weight between 44·5 and 59·4 kilos and have the vital capacity of 2·78 to 3·17 litres (1·97 to 2·02 litres per sq. m. surface area).

Body surface area was suggested by West (*loc. cit.*) as standard for vital capacity. It is evident from Table VI that the body surface area in Nokte Nagas is least variable but it has no significant correlation with vital capacity. The average vital capacity per sq. m. of body surface is 2·004 litres. Besides the result obtained by Mukherjee and Gupta (*loc. cit.*) no other worker in India obtained such a high value.

The relationship of vital capacity with age and pelidisi in Nokte Nagas is insignificant. Such observations were also made by Telang and Bhagwat (*loc. cit.*).

The Nokte Nagas have smaller anthropometric measurements than the average Indians but their vital capacity is almost the same with that of the Indians. Comparative measurements of average Indians and Nokte Nagas are respectively shown here: standing height—166·4 and 157·4 cm., sitting height—86·8 and 82·6 cm., weight—55·4 and 53·7 kilos and body surface area (Du Bois)—1·64 and 1·51 sq. m.

The coefficient of variation ranged from 2·05 for surface area to 23·95 for approximate age. The coefficient of variation for standing height is 3·42 and then come sitting height and pelidisi. Weight and vital capacity show a greater variation, respectively 10·0 and 15·19 per cent. Telang and Bhagwat (*loc. cit.*) obtained a variation of 15·97 per cent for vital capacity.

In Nokte Nagas the most significant correlation of vital capacity is with standing height and weight and next follows the correlation with sitting height and surface area.

The tribe has an average vital capacity of 3·035 litres, which is almost the same as that of the Indian average, shown in this paper. On the basis of earlier work the Indian average was found to be 2,982 and 2,949 respectively by Telang and Bhagwat and Reddy and Sastry. The vital capacity and the ratios between vital capacity and standing height and vital capacity and surface area in Nokte Nagas are almost the same with those values in the Chinese but these are much smaller than the corresponding Japanese, English and American standards. The results prove obviously that comparatively much cooler climatic conditions in this frontier hills and much more physical exercises of the tribe have practically no influence on their vital capacity. In them also physical builds play important rôle in the variation of their vital capacity.

Summary

The vital capacity of 140 adult male Nokte Nagas, inhabitant of the Tirap Frontier Division in N.E.F.A. was estimated with the help of a wet type spirometer, manufactured by C. F. Palmer Ltd., London, during March to June, 1954. Along with this, physical measurements of standing height, sitting height and weight of each subject were also taken. Body surface area (Du Bois method) and pelidisi, an index of nutrition, were also calculated from these measurements. Actual data showing the relation between vital capacity and other physical measurements are presented in five tables. Statistical data on ranges, means, standard deviations, coefficients of variation were computed for each measurement. Coefficients of correlation between vital capacity and standing height, sitting height, weight, body surface area in sq. m. and pelidisi were worked out. The results have been compared with the average Indian, Chinese, Japanese, English and American standards. The statistical correlation between vital capacity and standing height and weight are significant. Vital capacity and other related ratios in the Nokte Nagas are identical with those of the Indians, and Chinese but these are much lower than the average Japanese, English and American standards.

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