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The Vital Capacity of University Students

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Following an island-wide physical fitness survey conducted by the Department of Physiology and Pharmacology, University of Ceylon, Cullumbine (1949) observed that the vital capacity of Ceylonese subjects in regard to sex and age was much lower than the figures quoted for Western people. The Ceylonese male of the age group 21-25 years and height of 5 ft. 4 in.-5 ft. 6 in. had a mean vital capacity of 2·635 litres and the Ceylonese female adult had a vital capacity of 1·570 litres, whereas according to Peabody and Wentworth (1917) the corresponding figures for the Western male and female of similar age and height were 4·0 litres and 2·825 litres respectively.

Certain anomalies were noticed in that survey, for instance, the mean vital capacity of twelve year old boys was less than that of eleven year olds, although the samples examined were about the same size. Again the mean vital capacity at 20 years was less than that at 19 years but the mean vital capacity of the 21-25 year group was greater than that of the 19 year group. Similar anomalies were noticed among the female subjects, the 18 year old group having a lower vital capacity than the 17 year old group but the 19 and 20 year old groups having higher vital capacities than the 17 year old group. In the circumstances it was considered desirable to reinvestigate the subject particularly in the age group 18-25 years and the material was available in the form of some 500 University Freshmen of this age group.

Method

The vital capacity was measured on a calibrated wet spirometer. Attempts were made both in the sitting and the standing positions. Not less than three attempts were made by each subject at his or her convenience after becoming familiar with the procedure. The maximum vital capacity was usually reached about the second or third attempt. The best of the trials was taken as the maximum vital capacity. The results were expressed in litres corrected to a body temperature of 37°C.

Results

The mean vital capacity with the standard error of the mean for each year from − 18 to 25 + years for both male and female students is given in Table I.

TABLE I

The variation of vital capacity with age and sex in University Students

MALE				*FEMALE*		
Mean Vital Capacity in Litres	*S.e of Mean*	*No. of Subjects*	*AGE IN YEARS*	*No. of Subjects*	*Mean Vital Capacity in Litres*	*S.e of Mean*
3·44	± 0·230	5	17-18	11	2·46	± 0·141
3·26	± 0·070	57	18-19	32	2·07	± 0·065
3·36	± 0·047	78	19-20	35	2·16	± 0·072
3·29	± 0·057	76	20-21	29	2·12	± 0·065
3·29	± 0·057	47	21-22	21	2·13	± 0·103
3·31	± 0·074	44	22-23	10	2·29	± 0·114
3·18	± 0·250	6	23-24	3	2·49	± 0·143
3·27	± 0·136	6	24-25	2	1·85	± 0·080
3·19	± 0·085	24	25 +	3	1·82	± 0·163
3·30	± 0·023	343	all ages	146	2·16	± 0·032

The mean vital capacity of each age group is higher than the corresponding figures of the last survey. An increase of 0·6-0·9 litres was recorded. In the previous survey the mean vital capacity was 2·635 litres for the age group 21-25 years and in the present survey the mean vital capacity for all ages (18-25 + years) was 3·30 litres which is nearly 700 c.c. higher. In the present survey the mean vital capacity of the female population was 2·16 litres against 1·570 litres in the previous survey and for the age group 17-18 years the mean vital capacity was 2·46 litres. Here again an appreciable increase has been seen in the females. As the number of subjects examined in the age groups below 18 and above 25 are small, the results are presented in Table II with the age groups combined to give four groups between the ages of -19 to 23 + years. The comparatively small differences observed in the mean vital capacities between the ages of 18 and 25 years are not statistically significant. The results confirm the previous findings that the maximum vital capacity is reached by males between 18 and 25 years. Females reach a maximum vital capacity at between the ages of 18 and 24 years.

TABLE II

MALE				*FEMALE*		
Mean Vital Capacity in Litres	*S.e of Mean*	*No. of Subjects*	*AGE IN YEARS*	*No. of Subjects*	*Mean Vital Capacity in Litres*	*S.e of Mean*
3·28	± 0·063	62	17-19	43	2·17	± 0·065
3·33	± 0·034	154	19-21	64	2·14	± 0·051
3·30	± 0·037	91	21-23	31	2·18	± 0·077
3·19	± 0·075	36	23 +	8	2·08	± 0·136

Influence of Race on Vital Capacity

With regard to the influence of race on vital capacity we have figures which will only permit the comparison of the two majority communities, the Sinhalese and the Tamil with the Burghers. By Tamils we refer to Ceylon Tamils for the Indian Tamils at the University are an extremely small number and are included in Table III in the category ' others '.

TABLE III

Influence of race on vital capacity

MALE				*FEMALE*		
Mean Vital Capacity	*S.e of Mean*	*No. of Subjects*	*RACE*	*No. of Subjects*	*Mean Vital Capacity*	*S.e of Mean*
3·26	± 0·028	227	Sinhalese	97	2·16	± 0·038
3·31	± 0·049	98	C. Tamils	38	2·30	± 0·109
3·79	± 0·169	10	Burghers	8	2·30	± 0·109
3·66	± 0·140	8	Others	3	2·65	± 0·546

The Burgher male students appear to have the highest mean vital capacity. It is significantly greater than that of the Sinhalese ($p = < 0·01$). The vital capacity of the Burgher males is also significantly greater than that of the Ceylon Tamils ($p = 0·01$); Sinhalese males have a lower vital capacity than that of Tamil males but these differences in mean vital capacity are not significant. Among the females, the Burghers have a higher vital capacity than the Sinhalese or the Tamils and the Tamils have a lower vital capacity than the Sinhalese. Again these differences are not significant.

Vital capacity is a physiological character which is closely correlated with certain anthropometric characters. Of all these correlations the most reliable is that with body surface (Houssay, 1951). A suitable yardstick is required for comparing the vital capacities of people who differ from each other anthropometrically. For instance a small man will naturally have a lower vital capacity than a big man who should have a higher vital capacity. A direct comparison will be fallacious. A rational approach is to assess the degree of deviation of the observed vital capacity of the individual from his own norm. The difference between the actual observed vital capacity and his own norm is termed the residual. A man with a plus residual has a greater vital capacity than that of the average man of his own surface area. On the other hand, a minus residual means that the actual vital capacity is less than that of the average man of his own surface area. Cureton (1947) postulates that a high plus residual indicates that an individual very probably has a greater flexibility of the chest wall, greater strength and range of action of the diaphragm, inspiratory muscles and the expiratory muscles of abdomen and chest. In this sense therefore the residuals may be regarded as a criterion of physical fitness. For calculating an individual's norm, Cureton's (1936) prediction equation for *young men* has been employed. Viz.—

Vital Capacity (cu.ins.) = 309 (Surface Area in sq.m.) – 273

(corrected to 37°C);

or expressed entirely in the metric system.—

Vital Capacity (c.c.) = 5075 (Surface Area in sq.m.) – 4484

(corrected to 37°C).

Surface area is calculated from height and weight using the Boothby-Sandiford Nomogram reproduced by DuBois (1936).

The residual (difference between actual observed vital capacity and norm for the individual) is expressed as a plus or minus percentage of the norm. These results for the male students are given in Table IV.

TABLE IV

Classification	*Letter Grade*	*No. of Students*	%	
Above Norm (> + 45%)	A +	1	0·3	
Above Norm (+ 35% to + 45%)	A	2	0·6	
Above Norm (+ 25% to + 35%)	A –	10	3·1	Above Normal 24·6%
Above Norm (+ 15% to + 25%)	B +	16	5	
Above Norm (+ 5% to + 15%)	B	50	15·6	
Norm (– 5% to + 5%)	C +	88	27·5	Normal 27·5%
Below Norm (– 5% to – 15%)	C	101	31·6	
Below Norm (– 15% to – 25%)	D	42	13·1	
Below Norm (– 25% to – 35%)	D –	8	2·5	Below Normal 47·8%
Below Norm (– 35% to – 45%)	E	2	0·6	
Below Norm (– 45%)		0	0	
	TOTAL	320		

A deviation of ± 5% has been arbitrarily graded as the Norm. Of the 320 male students classified, 88 or 27·5% of the community have a normal vital capacity, while 101 or 31·6% are below their norm to the extent of 5-15% ; 42 or 13·1% are 15-25% below norm, and 10 or 3·1% are 25-45% below norm. On the other hand, 50 or 15·6% have a vital capacity of 5-15% above their norm and 16 or 5% are above their normal to the extent of 15-25% ; 12 or 3·6% have a vital capacity 25-45% above normal. Only 1 (champion swimmer) has a vital capacity over 45% greater than his norm. To summarise 27·5% have vital capacities equal to their norms (residual nil), 24·6% have a plus residual and 47·8% have minus residuals.

Discussion

It is well established that the vital capacity varies with size and is related to certain anthropometric characters. It is highly correlated with surface area, height, weight, chest circumference, etc. (Whipple, 1910 ; Jackson and Lees, 1929 ; West, 1920 ; McCloy, 1927). The Ceylonese people are of small physique compared to the Western races and have a smaller surface area. Consequently their vital capacities will be expected to be lower than those of Western people. The first survey of the vital capacity of Ceylonese by Cullumbine (1949) disclosed that the highest mean vital capacity was reached by males between the ages of 19 and 25 years and amounted to 2·635 litres, the highest vital capacity of Ceylonese females was attained at between 19 and 20 years and was only 1·570 litres, whereas the corresponding figures for Western people of the same age and height were 4·0 litres for males and 2·826 litres for females. The present survey provides higher figures for both sexes. The maximum vital capacity is attained between the ages of 18 and 25 years and amounted to 3·30 litres for males, while the females reached a maximum capacity of 2·46 litres at between 18 and 29 years. An increase of 0·7 litres in males and about 0·9 litres in females being recorded which represented an increase of about 25-60% over the first survey. The disparity now between Ceylonese and Western standards is less striking. The appreciable rise in the vital capacity recorded in this survey may be due to (1) the fact that we are dealing with a biased sample consisting of University Freshmen, drawn principally from higher socio-economic levels, educated at schools and colleges with facilities for physical recreation (2) the interest now taken in physical training and physical education and (3) a technical reason, in that these vital capacity values have been corrected for body temperature (37°C) which will result in a 3% increase in the vital capacity observed at laboratory temperature.

With regard to the influence of race on vital capacity, this survey confirms the findings of the previous survey. Burghers who are of Western extract have the highest vital capacities of the three communities studied. (Vide Table III) Burgher males have a significantly higher vital capacity than that of the Sinhalese or Tamils. The Burgher females also have highest vital capacities but the differences between them and the Sinhalese and Tamil females is not significant.

A comparison of the vital capacities of Ceylonese youths with their norms indicates that as much as 47·8% have minus residuals. In other words nearly 50% of our students are below their respective norms. These figures compare unfavourably with those for American students. Cureton's prediction equation applied to Illinois Medical School Students show that about 10% are below their norms. It must be admitted that medical students constitute about 25% only of our sample but this is of little significance as the performance of our medical students in athletics and games is little or no better than that of university students in general. It is unlikely that a sample of medical freshmen alone would have produced results appreciably different from the above. The fact remains that of the pick of the youth of Ceylon about 50% have vital capacities below normal.

There is overwhelming evidence that the vital capacity is lowered in disease. Certain pulmonary and cardiac disorders rank high as causes of low vital capacity. But the vital capacity is reduced by conditions also like ankylosis of the costal joints, muscular weakness, especially of the intercostal muscles. Shepherd (1924) claims

that certain past diseases like pneumonia and influenza reduce vital capacity. Peabody and Wentworth (1917) believe that people with low vital capacity need a good medical examination and Amar (1920) states that a fall of 20% in vital capacity is suggestive of pulmonary disease. The trend is to regard vital capacity as an index of fitness. In this connection the significant vital capacity measurement is the residual which Cureton (1947) considers a true fitness measure. Vital capacity is correlated directly with endurance time (Cullumbine and Williams, 1949). Vital capacity increases with training (White and McGuire, 1925; Ricker, 1930). Swimming, regular breathing exercises and chest stretching exercises can definitely increase vital capacity. Swimming makes great demands on the respiratory mechanisms. Ricker (1930) found that one group of boy swimmers increased their vital capacities 57% more than a matched group of boys doing gymnastics. Cureton (1947) postulates that swimming promotes unusual development of the inspiratory chest muscles and diaphragm, because between 200-300 pounds of water pressure are pushed backwards during chest expansion. Swimmers consistently have high positive residuals. In fact our highest positive residual was recorded in a swimming champion of Ceylon. In view of the above observations that vital capacity or vital capacity residual is an index of fitness, it appears that nearly 50% of university freshmen are below the normal fitness index.

Life in a residential university with facilities for physical exercise under expert supervision should yield dividends. These freshmen after a couple of years of residence should improve in their performance. This is a matter that calls for future investigation.

Summary

The vital capacity of Ceylon University students has been studied. The mean vital capacity of males was 3·30 litres and that of females 2·16 litres. These vital capacities are appreciably higher than those recorded previously for Ceylonese.

Of the three communities, Sinhalese, Tamils and Burghers, the last have the highest vital capacity for both males and females. The vital capacity of the Sinhalese is not significantly different from that of the Tamils.

47·8% of male students have minus residuals and their actual observed vital capacities are less than their own norms.

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References

AMAR, J., (1920) *Physiological Abstracts*, 5, 88.

CULLUMBINE, H., (1949) *Journal of the Ceylon Branch of the British Medical Association*, 44, 17.

CULLUMBINE, H. and WILLIAMS, K., (1949) *Cey. J. Med. Sci.*, 6, 1.

CURETON, T. K., (1936) *The Research Quarterly*, 7, 80.

CURETON, T. K., (1947) *Physical Fitness Appraisal and Guidance*. p. 337, Henry Kimpton, London.

DUBOIS, E. F., (1936) *Basal Metabolism in Health and Disease*. 3rd ed., p. 133, Bailliere, Tindall and Cox, London.

HOUSSAY, B. A., (1951) *Human Physiology.* 1st ed., p. 239. McGraw-Hill Book Company, Inc., U.S.A.

JACKSON, C. M. and LEES, L. D., (1929) *Amer. J. Physiol.*, 87, 654.

MCCLOY, C. H., (1927) *Arch. int. Med.*, 40, 686.

PEABODY, F. W. and WENTWORTH, J. D., (1917) *Arch. int. Med.*, 20, 443.

RICKER, L. D., (1930) *Swimming as a factor in Physical and Health Education Master's thesis.* Akron University.

SHEPHERD, W. P., (1924) *Arch. int. Med.*, 33, 425.

WEST, H. F., (1920) *Arch. int. Med.*, 25, 306.

WHIPPLE, G. M., (1910) *Manual of Mental and Physical Tests.* p. 70, Warwick and York, Inc.

WHITE, S. A. and MCGUIRE, P. F., (1925) *Arch. int. Med.*, 36, 355.