PHYSICAL MEASUREMENTS OF ADOLESCENT SCHOOL-BOYS IN RELATION TO SCHOLASTIC ATTAINMENT AND PROWESS IN GAMES AND SPORTS.

By ALFRED A. MUMFORD.

The following study completes the examination of the data derived from certain physical and physiological measurings of adolescent boys at the Manchester Grammar School, taken during the last ten years with a view to enquiring whether any definite relationship could be discovered between such measurings, considered singly or in combination, and either general scholastic attainments or special aptitudes in school sports and games. If such relationship, indicating either general or particular aspects of health and vitality, could be discovered, then, although spontaneity of choice in classroom and playing-fields should always be jealously guarded, yet the cause of many failures might be revealed and such innate energy as the boy may possess be directed into more appropriate channels.

Part I of this paper is concerned with the physical growth of the senior boys in relation to scholastic attainments and to prowess in games and sports. Part II is concerned with scholastic attainments in relation to prowess in games and sports. Part III is concerned with physical growth in relation to prowess in individual games and sports, and forms the conclusion of the work on *special* body proportions in relation to physical aptitude (*see* Mumford, 1930, this *Journal*).

Part I. The relation of growth to athletic prowess and to scholastic attainment.

(*a*) *Measurements taken.*

The data used in this enquiry are observations made on 797 Manchester Grammar School boys during the years 1922–8. All the boys considered had remained at school until they had attained the age of 17 years or later. The measurements taken were grouped according to age, and were

(i) Height in centimetres.
(ii) Weight in kilograms.
(iii) Chest girth in centimetres.
(iv) Vital capacity in cubic centimetres.

(*b*) *Method of measurement.*

Heights were taken without shoes; weight in gymnasium costume, also without shoes; chest girth with chest bare and in a resting position neither

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

inflated nor deflated; vital capacity with the wet spirometer, which was regularly re-examined at the testing station. It was found that, owing to the perishing of the leather, Boulite's dry spirometer after a while proved unreliable.

(*c*) *Indices.*

From the above measurements certain indices were calculated which it was hoped might throw additional light on the problems of growth studied.

$$\text{Buoyancy Index}^1 = \frac{\text{Weight}}{\text{Height} \times (\text{Chest Girth})^2} \times 10^7.$$

$$\text{Respiratory Index}^1 = \frac{\text{Vital Capacity}}{\text{Height} \times (\text{Chest Girth})^2} \times 10^5.$$

$$\text{Vital Index}^1 = \frac{\text{Vital Capacity}}{\text{Weight}} \times 10.$$

The reasons which led to the adoption of the Buoyancy Index and the justification for its use as a suitable expression for the specific gravity of a healthy adolescent schoolboy by comparison with actual measurings in the swimming bath, together with the range of the variability of the index and certain limitations to its reliability in extreme cases, are given in Mumford (1927, pp. 125–37). The Respiratory Index was adopted to express the relation of the volume of air exchangeable at a single effort to the total volume of the body. As the air which remains stationary in the chest is considerably larger than the air which is exchanged, this index becomes an expression of the relation between respiratory income and respiratory capital. Like the Buoyancy Index, it is remarkably constant in healthy boys, but its health significance is still somewhat obscure. The Vital Index has been much used as an expression of physical vigour by Baldwin (1914) in America. It will be seen in the sequel how far the usefulness of these indices has been proved.

(*d*) *Scholastic and athletic groupings.*

The boys were divided into three scholastic groups:

A. A group of 343 boys who not only passed the School Certificate examination, but did so at the higher (matriculation) level, and at a sufficiently early age to be prepared to stay at the school for another two years. They had all been promoted into one of the sixth forms, where they were tested two years later in their special subjects at the Higher School examination, which represents the first stage of University training. They may be designated *boys of advanced scholarship.*

B. A group of 201 boys who had also passed the School Certificate examination, sometimes but by no means frequently at matriculation level, always

[1] In order to reduce the labour and time involved in calculating the above indices, a nomograph was constructed by Mr H. Lob, Mathematical Master at the School, for calculating the first two indices. The Vital Index was calculated by slide rule. In a class of 30 boys all the three indices could then be calculated in 40 min.

at a somewhat later age—twelve to eighteen months or more—and in many cases at a second trial. They may be designated *boys of medium scholarship*.

C. A group of 253 boys who, though they had remained at the school until the age of 17 and were therefore comparable with the others in social circumstance and educational opportunities, had failed to obtain sufficient marks to pass the School Certificate examination, though they had generally been placed in classes preparing for it. They may be designated *boys of slow scholarship*.

Each of the groups A, B and C was then divided into two sub-groups according to whether the boys had or had not won colours for prowess at school games or credits for excellence at athletic sports or other physical activities. A 1, B 1, C 1 obtained colours or credits, A 2, B 2, C 2 did not.

(*e*) *Results*.

The mean standard deviation and coefficient of variation were tabulated for each measurement in each group[1], the main results are shown in Tables I and II. In Table I both absolute values are given and the values when the corresponding measurement in group C 2 is taken as 100. Comparisons between the athletic and the non-athletic groups, and between the three scholarship groups, may be made with the aid of Table I, but this is facilitated by the use of Table II from which the salient facts may easily be picked out. For the sake of clearness ages 16 and 18 have been omitted from the latter table, but these may be found in Table I, if required. The following conclusions may be drawn.

(1) In each of the three groups, that is of boys of advanced, of medium and of slow scholarship, those who won colours at games or credits at sports appear to have attained a greater growth at each age than those who did not obtain colours or credits. Exceptions occur in the height measurements of the 18-year-old group, and in their chest measurements in group A. The 18-year-old group, however, does not consist of exactly the same boys as the 15-, 16- and 17-year-old groups, since a number of exceptionally clever boys, who otherwise would have been included among the 18-year-olds, had left the school before the time of measuring.

(2) Within each of the two athletic groups, namely those who do and those who do not obtain colours and credits, increased growth at a given age is associated with more advanced scholarship. We find that the boys of advanced scholarship are ahead in growth of the boys of medium scholarship and the boys of medium scholarship are ahead of the boys of slower scholarship. The differences are small and in many cases not statistically significant, but the above inference is justified by the general uniformity. Exceptions occur in weight at ages 16 and 17 and in chest girth at ages 16, 17 and 18, where, in the group gaining colours and credits, the boys of medium scholar-

[1] For reasons of economy this table is not published here; it is available for consultation by those interested.

Table I. *Measurements of boys. Mean values for various groups.*

Group*	Mean values at age				Mean values as percentage of mean of group C 2 at age			
	15	16	17	18	15	16	17	18
Height (cm.):								
A 1	163·8	168·9	171·4	172·6	102·2	101·8	101·1	100·5
A 2	163·2	168·3	171·1	172·7	101·9	101·4	100·9	100·6
B 1	163·0	167·8	171·6	171·3	101·7	101·1	101·2	99·8
B 2	162·0	167·4	170·6	171·7	101·1	100·9	100·6	100·0
C 1	161·3	166·4	170·0	171·0	100·7	100·3	100·2	99·6
C 2	160·2	165·9	169·6	171·7	100·0	100·0	100·0	100·0
Weight (kg.):								
A 1	52·6	57·4	60·3	62·8	112·4	110·4	106·9	107·9
A 2	51·1	55·5	59·1	61·1	109·2	106·7	104·5	105·0
B 1	51·4	57·7	61·6	62·0	109·8	111·0	109·2	106·5
B 2	48·8	54·6	58·1	58·6	104·3	105·0	103·0	100·7
C 1	49·5	55·1	59·2	60·2	105·8	105·6	105·0	103·4
C 2	46·8	52·0	56·4	58·2	100·0	100·0	100·0	100·0
Chest Girth (cm.):								
A 1	77·1	80·2	82·7	81·0	104·8	104·7	104·3	100·1
A 2	75·9	79·0	81·1	82·8	103·1	103·1	102·3	102·3
B 1	76·8	80·4	83·5	85·2	104·3	105·0	105·3	105·3
B 2	74·9	78·2	80·7	82·7	101·8	102·1	101·8	102·2
C 1	76·2	80·2	82·8	83·9	103·5	104·5	104·4	103·7
C 2	73·6	76·6	79·3	80·9	100·0	100·0	100·0	100·0
Vital Capacity (c.cm.):								
A 1	3384	3738	3967	4136	113·4	112·6	108·8	108·2
A 2	3264	3586	3829	4003	109·4	108·0	105·0	104·7
B 1	3344	3732	4009	4138	112·1	112·4	110·0	108·2
B 2	3116	3505	3772	3931	104·5	105·6	103·5	102·8
C 1	3081	3483	3805	3975	103·3	104·9	104·4	104·0
C 2	2983	3319	3645	3823	100·0	100·0	100·0	100·0
Buoyancy Index:								
A 1	536	540	531	529	97·5	98·5	98·2	99·1
A 2	543	545	540	535	98·7	99·5	99·8	100·2
B 1	539	544	532	516	98·0	99·3	98·3	96·6
B 2	547	545	540	536	99·5	99·5	99·8	100·4
C 1	535	533	528	521	97·3	97·3	97·6	97·6
C 2	550	548	541	534	100·0	100·0	100·0	100·0
Respiratory Index:								
A 1	347	352	349	349	99·1	100·6	99·7	100·0
A 2	351	354	352	351	100·3	101·1	100·6	100·6
B 1	353	350	344	342	100·9	100·0	98·3	98·0
B 2	351	350	349	348	100·3	100·0	99·7	99·7
C 1	337	339	341	341	96·3	96·9	97·4	97·7
C 2	350	350	350	349	100·0	100·0	100·0	100·0
Vital Index:								
A 1	642	649	655	656	100·3	101·1	101·1	99·8
A 2	639	649	652	655	98·8	101·1	100·6	99·7
B 1	655	656	649	641	102·3	102·2	100·2	97·6
B 2	641	644	653	655	100·2	100·3	100·8	99·7
C 1	631	635	644	651	98·6	98·9	99·4	99·1
C 2	640	642	648	657	100·0	100·0	100·0	100·0

* A 1 = Advanced scholars winning colours at games or credits at sports.
A 2 = Advanced scholars not winning colours at games or credits at sports.
B 1 = Medium scholars winning colours at games or credits at sports.
B 2 = Medium scholars not winning colours at games or credits at sports.
C 1 = Slower scholars winning colours at games or credits at sports.
C 2 = Slower scholars not winning colours at games or credits at sports.

ship show a slight advantage over those of advanced scholarship. Among these exceptions, however, the difference is only statistically significant for the chest measurements at age 18. Definite, though slight, loss of chest girth and of girth of upper and lower arm, with consequent loss of weight, were the first

Table II. *Mean measurements of various groups of boys expressed as a percentage of the mean of group C 2. Data from Table I arranged so as to allow comparison between the three groups of boys winning colours at games and between the three groups not winning colours. Ages* 15 *and* 17.

Group*	Age 15	Age 17	Group*	Age 15	Age 17
Height:			Height:		
A 1	102·2	101·1	A 2	101·9	100·9
B 1	101·7	101·2	B 2	101·1	100·6
C 1	100·7	100·2	C 2	100·0	100·0
Weight:			Weight:		
A 1	112·4	106·9	A 2	109·2	104·5
B 1	109·8	109·2	B 2	104·3	103·0
C 1	105·8	105·0	C 2	100·0	100·0
Chest Girth:			Chest Girth:		
A 1	104·8	104·3	A 2	103·1	102·3
B 1	104·3	105·3	B 2	101·8	101·8
C 1	103·5	104·4	C 2	100·0	100·0
Vital Capacity:			Vital Capacity:		
A 1	113·4	108·8	A 2	109·4	105·0
B 1	112·1	110·0	B 2	104·5	103·5
C 1	103·3	104·4	C 2	100·0	100·0
Buoyancy Index:			Buoyancy Index:		
A 1	97·5	98·2	A 2	98·7	99·8
B 1	98·0	98·3	B 2	99·5	99·8
C 1	97·3	97·6	C 2	100·0	100·0
Respiratory Index:			Respiratory Index:		
A 1	99·1	99·7	A 2	100·3	100·6
B 1	100·9	98·3	B 2	100·3	99·7
C 1	96·3	97·4	C 2	100·0	100·0
Vital Index:			Vital Index:		
A 1	100·3	101·1	A 2	99·8	100·6
B 1	102·3	100·2	B 2	100·2	100·8
C 1	98·6	99·4	C 2	100·0	100·0

* A 1 = Advanced scholars winning colours at games or credits at sports.
B 1 = *Medium* scholars winning colours at games or credits at sports.
C 1 = Slower scholars winning colours at games or credits at sports.
A 2 = Advanced scholars not winning colours at games or credits at sports.
B 2 = *Medium* scholars not winning colours at games or credits at sports.
C 2 = Slower scholars not winning colours at games or credits at sports.

signs of excessive hours of study noticed among boys of the sixth forms working for University scholarships. Observations on the same boys after a proper holiday showed that the loss was temporary in nature (see Mumford, 1911). All the physical measurements are taken just before the Whitsuntide holidays, *i.e.* at the time of greatest examinational pressure.

(3) At age 17, when adolescence has become fully established, there is also some lack of uniformity in the result, and the differences are on the whole smaller than at age 15.

(4) From (1) and (2) it may be concluded that, in this socially and mentally considerably specialised group of 797 boys attending the upper part of the Manchester Grammar School, the boys with advanced scholastic attainments are more advanced in growth than those of lower mental attainments, especially at the age of 15, and that within the same mental grade those winning colours at games or credits at sports are more advanced in growth than those who do not win colours or credits.

(5) The conclusion (4) is true, not only of physical growth, but also of vital capacity, that is, of physiological activity.

(6) The differences in Buoyancy Index between the various groups are very small. The winners of colours or credits in each of the three scholarship groups are, however, of lighter specific gravity, that is, more buoyant in body than the non-winners of colours and credits in the same groups. Among those boys who do not win colours or credits, the boys of more advanced scholarship are more buoyant than those of medium scholarship, and those of medium scholarship more buoyant than those of slower scholarship. Among the winners of colours and credits there appears to be no relation between good scholarship and buoyancy. This class is already select for buoyancy and the further effect of the physical substratum of good scholarship made little if any difference. Earlier enquiries (Mumford, 1927, pp. 251–2) have shown that both the good scholars and the good gymnasts have better buoyancy than the mean or average boy of the school at all ages, except perhaps at 18, where, as already stated, the group becomes small owing to the more intellectually advanced boys having left, and those remaining being subject to considerable pressure to help them win the scholarships they needed in order to obtain University training. A similar relationship between facility in acquiring knowledge and greater buoyancy has been revealed in the case of the "quick pack" of medical students as compared with the "slow pack" at Manchester University (see *Ibid.* p. 254).

(7) The differences in respiratory index between the different groups are not statistically significant, with one exception, that is C 1 at age 15, which is the lowest value of all, and differs significantly from B 1 at the same age.

(8) There are no significant differences in the Vital Index.

(9) With regard to the non-significance of these two latter indices, it may be noted (*a*) that their precise physiological value has not yet been determined, and (*b*) that the vital index does not take chest girth into account. All previous researches (*Ibid.* pp. 254, 257–9, and 318–20) at the Manchester Grammar School and elsewhere have shown the great importance of ample chest girth with consequent ample reserves of oxygen.

Part II. Prowess in games and sports in relation to scholastic attainment.

It may be observed that among the 343 boys in group A, 120 won scholarships at Oxford or Cambridge and 91 were entrants for degree courses at Manchester University, that is to say 62 per cent. subsequently studied at Universities. Of the 201 boys in group B, none won scholarships at Oxford or Cambridge, but 65 (or 32 per cent.) pursued degree courses at Manchester. Of the 253 boys in group C, 16 (or 6 per cent.) entered at Manchester, mostly for special courses other than the full degree courses.

Table III. *Actual and expected numbers of colours and credits.*

	No. of colours for prowess at school games awarded to boys in each group					No. of credits for prowess at school sports awarded to boys in each group						Total number of boys winning colours o credits or both
	All games	Cricket	Soccer	Rugby	Lacrosse	Total credits	Swim-ming	Gym	Harriers	Sprint-ing	Broad or high jumping	
Group A, 343 boys:												
Actual	97	27	33	24	13	57	8	9	22	12	6	129
Expected	72	17	23	17	15	60	12	11	23	10	5	108
Group B, 201 boys:												
Actual	33	8	11	7	7	35	9	4	17	5	2	51
Expected	42	10	13	10	9	35	7	7	13	6	3	63
Group C, 253 boys:												
Actual	37	4	9	9	15	47	11	13	14	7	3	71
Expected	53	12	17	13	11	44	9	8	17	8	3	80

In Table III an analysis is made of the various colours in games and credits in sports gained in each group. The total number of colours and credits awarded for each game and sport is shown and also the expected numbers that would have been obtained had the colours and credits gained in each group been proportional to the number of boys in the group. In group A it is found that more than the expected number of colours was gained by the boys in the team games, in groups B and C less than the expected number, though, as regards feats involving individual athletic prowess, the differences between the two groups are not significant. Possibly the greater intelligence of boys of advanced scholarship shows itself in the performance of team games where the measure of intelligence demanded for combined purpose is often greater than that required for feats of individual prowess (see Schulman, 1930)[1].

That the relationship shown to exist between physical prowess during school life and the standard of scholastic attainment revealed in the results

[1] It is interesting to note that a study by Herman Schulman of the Scholarship of students participating in extra curricula activities showed that "where the athletes are selected from among students superior to the average, a high standing in scholarship will be maintained both in and out of the season of such activity. The additional drain upon the time and vitality of students occasioned by their participation in athletics is negligible from the point of view of scholarship." *Bulletin of High Points in the Work of the High Schools of New York City*, Sept. 1930.

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

of examinations of a more advanced nature than the School Certificate examination is equally definite is shown by the following facts which have been arrived at during the course of earlier enquiries. During the years 1923–6, a series of 231 boys, after passing the School Certificate examination, had studied a further two years in one of the sixth forms and presented themselves for the Higher School Certificate examination. They were divided into three equal groups according to the number of marks they obtained. We were advised that the number of marks obtained by Tertile I could be regarded as equal to first-class intermediate University honours; the marks gained by Tertile II as equal to a second-class intermediate University honours, and those of Tertile III could be regarded as a failure to obtain intermediate University honours. The total number of colours in games and credits at

Table IV. *Relative number of colours for school games or credits for sports obtained by* 215 *boys winning entrance scholarships at Oxford or Cambridge according to the class obtained in subsequent University honours.*

	Total no. of colours or credits gained by the group	Total no. of boys gaining colours or credits
102 boys obtaining one or more first-class honours	Actual 45 (44 %)	27 (26 %)
	Expected 34 (33 %)	22 (21 %)
72 boys obtaining second-class honours only	Actual 18 (25 %)	14 (19 %)
	Expected 24 (33 %)	16 (22 %)
41 boys obtaining third-class honours only	Actual 9 (22 %)	6 (15 %)
	Expected 14 (34 %)	9 (22 %)

sports gained by the 231 boys was 98. They were distributed as follows: 41 to Tertile I, 26 to Tertile II, 31 to Tertile III, a result which suggested that, if other factors than chance were operative, boys of high attainment played more games and won more credits than boys of lesser attainment; the means of their buoyancy indices were 530·6, 531 and 534·6 respectively.

Lastly, the relation between participation in physical activities during school life and subsequent University career was considered among a series of 215 boys who won entrance scholarships at Oxford or Cambridge (see Mumford, 1929). The essential results, as far as they concern us here, are shown in Table IV. We see that those who obtained first-class University honours had won more games colours and sports credits while at school than those who obtained only second-class honours. The latter in their turn had obtained more colours and credits than those who gained only third-class honours. Further, the number of colours and credits which had been gained by those who obtained first-class honours was significantly in excess of expectation.

Part III. Physical growth in relation to prowess in individual games and sports.

The relationship between special body proportions, *e.g.* limb, shoulder girth, etc., as distinct from the more general body measurements usually taken, and the special physical activities displayed was considered in the previous paper already referred to (Mumford, 1930). The present enquiry deals only with the measurements in general use. The data were extracted from the records of the 231 boys already considered who had obtained colours in sports or credits in games. The boys were divided into two groups: (1) those gaining colours or credits in one game or sport only, the game or sport being specified; (2) those gaining colours or credits in the specified game and at least one other. Only the measurements at 15 and 16 were considered. From Tables V and VI (p. 90–94) it may be concluded that:

(1) There are significant differences in height and weight at both ages in the different games groups. At both ages whether we consider those who play the specified game only or those who in addition play other games, the order for height is much the same as for weight. The successful rugger players, cricketers, swimmers and sprinters are relatively tall and heavy, the successful gymnasts and long distance runners relatively short and light. The successful high jumpers[1] who also distinguish themselves at other sports are the tallest and heaviest group of all and the broad jumpers are not far behind them.

(2) In the chest measurements only one out of the four sets tested definitely shows statistical significance, but the order is closely similar to that of the height and weight measurements and suggests that the successful rugger players, cricketers, swimmers and sprinters are relatively wide-chested; the successful gymnasts and long-distance runners relatively smaller chested. This is perhaps connected with their lesser height. Jumpers who also distinguish themselves at other sports have wide chests.

(3) In vital capacity there are again no significant differences, but resemblances between the order for vital capacity and the order for height, weight and chest girth can nevertheless again be detected. Rugger players, cricketers and sprinters appear relatively high up on the list, and gymnasts and long distance runners relatively low. Those who won credits for both high and broad jump are at the top at age 15, and at age 16 the high jumpers are only beaten by the rugger players, and the broad jumpers by the rugger players and sprinters.

(4) No significant differences in buoyancy are noted at age 15, but there is some significance in the differences at age 16. Successful gymnasts and swimmers are then relatively more buoyant, lacrosse players relatively less buoyant.

(5) In the respiratory and vital indices there are no significant differences.

[1] Naturally no conclusion can be drawn from the two boys who distinguish themselves in high jump only.

(6) A fuller physiological significance is given to the above comparison of one type of athletic aptitude with another by considering the findings in connection with the time increment charts of Varieties of Physical Fitness (see Mumford, 1927, pp. 178–91), where the separate athletic types are compared with the normal boy, showing, in terms of time increment, how far the former are ahead of the latter in all measurements at all ages.

The statistical method followed in reaching the above conclusions is as follows:

For each of the two classes the mean measurements at ages 15 and 16 were obtained and the significance of the differences between the measurements of those distinguishing themselves at the different games or sports was tested by a simple application of the analysis of variance method. For instance if we consider *height* at age 15, there were 129 boys each of whom got a colour or credit in one game or sport only. Table V shows us that there were nine classes of games or sport. The sum of the squares of the deviations of all the height measurements from their mean was 9417·9; this is made up of two items, an amount of 7801·0, which is the sum of the squares of the deviations of the measurements from the mean of their own class, and the remainder 1616·9, due to variations from class to class. We have in all 128 degrees of freedom, of which 120 are due to differences within classes and the remaining 8 to differences between classes. Dividing the above two items by the corresponding number of degrees of freedom, we obtain estimates of the variance within and between classes. If there is no significant difference in height between the different classes, these two estimates should be equal, except for fluctuations of sampling. Actually the variance due to differences between classes is significantly greater, as may be shown by the z test[1]. The actual analysis is as follows:

	Sum of squares	Degrees of freedom	Mean square
Within classes	7801·0	120	65·01
Between classes	1616·9	8	202·89
	9417·9	128	—

$$z = 0{\cdot}57 \left\{ \begin{matrix} 5\ \%\ \text{point} = 0{\cdot}35 \\ 1\ \%\ \text{point} = 0{\cdot}49 \end{matrix} \right\}.$$

The standard error of the mean of any class may then be obtained by dividing the figure 65·01 by the number in the class and taking the square root.

Tables V and VI show the results obtained by this method.

[1] This test is applied by calculating $z = \frac{1}{2} \log \frac{v_1}{v_2}$, where v_1 = variance due to difference between different games, v_2 = variance due to difference between individuals playing the same game. If the differences between the different games are not significant, v_1 and v_2 should be approximately equal, differing only owing to fluctuations of sampling. If v_1 and v_2 are equal, z is zero. It is possible to calculate the probability of obtaining a z greater than any assigned value merely by chance, if there is really no difference between the different games. Actually the 5 per cent. and 1 per cent. points of the distribution of z, that is to say, the values which would only occur by chance once in 20 or once in 100 times, have been calculated. So the procedure is to calculate z and determine the 5 per cent. point from a table. If z is greater than the 5 per cent. point, this means that the differences between the different games are, as a whole, significant (or rather that the chances are more than 19 in 20 that this is so).

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

Table V. *Age* 15.

	Those gaining colours or credits in one game only			Those gaining colours or credits in the game mentioned and at least one other		
		Height			Height	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	19	167·2	1·8	32	165·8	1·4
Cricket	17	166·2	2·0	42	164·4	1·3
Sprinters	9	164·6	2·7	33	164·0	1·4
Swimming	9	163·5	2·7	18	162·7	1·9
High jump	2	163·0	5·7	16	168·2	2·0
Soccer	22	161·9	1·7	53	162·5	1·1
Lacrosse	23	161·3	1·7	34	162·4	1·4
Gym	15	158·2	2·1	24	158·9	1·7
L.D.R.[1]	13	155·7	2·2	34	160·5	1·4
Broad jump	—	—	—	6	166·9	3·3
	$z=0{\cdot}57$ {5 % point = 0·35; 1 % point = 0·49}			$z=0{\cdot}48$ {5 % point = 0·32; 1 % point = 0·45}		
	Significant			Significant		
		Weight			Weight	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	19	55·8	1·7	32	55·0	1·3
Swimming	9	53·3	2·5	18	53·1	1·7
Cricket	17	52·6	1·8	42	52·4	1·1
Sprinters	9	52·0	2·5	33	52·4	1·3
High jump	2	51·8	5·2	16	56·1	1·8
Soccer	22	50·5	1·6	53	51·5	1·0
Lacrosse	23	48·6	1·5	34	50·6	1·3
Gym	15	47·4	1·9	24	48·3	1·5
L.D.R.	13	44·2	2·0	34	48·9	1·3
Broad jump	—	—	—	6	54·0	3·0
	$z=0{\cdot}60$ {5 % point = 0·35; 1 % point = 0·49}			$z=0{\cdot}51$ {5 % point = 0·32; 1 % point = 0·45}		
	Significant			Significant		
		Chest			Chest	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	19	78·7	1·1	32	78·3	0·8
Swimming	9	78·0	1·6	18	78·2	1·1
Cricket	17	77·7	1·2	42	77·7	0·7
Sprinters	9	77·2	1·6	33	77·3	0·8
Soccer	22	76·0	1·0	53	76·7	0·6
High jump	2	75·8	3·3	16	79·2	1·2
Gym	15	75·3	1·2	24	75·8	1·0
Lacrosse	23	74·2	1·0	34	75·8	0·8
L.D.R.	13	73·9	1·3	34	75·7	0·8
Broad jump	—	—	—	6	78·3	1·9
	$z=0{\cdot}33$ (5 % point = 0·35)			$z=0{\cdot}25$ (5 % point = 0·32)		
	Not significant (but close to borderline)			Not significant		

[1] L.D.R. = Long distance running.

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

Table V. *Age* 15 (continued).

	Those gaining colours or credits in one game only			Those gaining colours or credits in the game mentioned and at least one other		
		Vital Capacity			Vital Capacity	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	19	3537	137	31	3458	121
Sprinters	8	3491	201	29	3442	125
Cricket	15	3309	154	35	3248	114
Soccer	20	3186	133	46	3273	99
High jump	2	3085	411	14	3544	180
Gym	12	3076	172	19	3187	154
Swimming	7	3064	225	16	3247	168
Lacrosse	20	2985	133	31	3143	121
L.D.R.	12	2874	172	30	3171	123
Broad jump	—	—	—	6	3487	274
	$z=0{\cdot}34$ (5 % point $=0{\cdot}35$) Not significant (but close to borderline)			$z=0{\cdot}02$ (5 % point $=0{\cdot}33$) Not significant		

		Buoyancy Index			Buoyancy Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
High jump	2	553·5	20·1	16	531·6	6·3
Lacrosse	23	544·1	6·2	34	540·6	4·3
Soccer	22	538·1	6·3	53	536·1	3·5
Rugger	19	537·8	6·8	32	539·4	4·5
Swimming	9	535·7	9·8	18	532·2	6·0
Sprinters	9	531·4	9·8	33	533·2	4·4
Gym	15	524·7	7·6	24	524·6	5·2
Cricket	17	521·8	7·2	42	525·9	3·9
L.D.R.	13	516·9	8·2	34	528·5	4·3
Broad jump	—	—	—	6	527·7	10·3
	$z=0{\cdot}24$ (5 % point $=0{\cdot}35$) Not significant			$z=0{\cdot}20$ (5 % point $=0{\cdot}32$) Not significant		

		Respiratory Index			Respiratory Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Sprinters	8	352·3	13·8	29	347·0	7·1
Soccer	20	340·4	8·7	46	341·7	5·7
Rugger	19	339·4	9·0	31	339·3	6·9
Lacrosse	20	334·7	8·7	31	333·7	6·9
Gym	12	334·5	11·3	19	338·9	8·8
L.D.R.	12	334·3	11·3	30	346·5	7·0
High jump	2	328·0	27·6	14	332·7	10·2
Cricket	15	323·0	10·1	35	332·5	6·5
Swimming	7	322·4	14·8	16	332·2	9·6
Broad jump	—	—	—	6	340·0	15·7
	$z=-0{\cdot}30$ (5 % point $=0{\cdot}35$) Not significant			$z=-0{\cdot}28$ Not significant		

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

Table V. *Age* 15 (continued).

	Those gaining colours or credits in one game only			Those gaining colours or credits in the game mentioned and at least one other		
		Vital Index			Vital Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Sprinters	8	662·9	27·7	29	648·4	13·7
L.D.R.	12	649·8	22·6	30	655·4	13·5
Gym	12	636·1	22·6	19	644·3	16·9
Rugger	19	633·7	18·0	31	628·3	13·3
Soccer	20	631·4	17·5	46	636·2	10·9
Cricket	15	623·3	20·3	35	633·6	12·5
Lacrosse	20	616·3	17·5	31	619·1	13·3
High jump	2	595·0	55·5	14	623·4	19·7
Swimming	7	593·1	29·6	16	621·0	18·5
Broad jump	—	—	—	6	645·2	30·1
	$z = -0{\cdot}24$ (5 % point $= 0{\cdot}35$) Not significant			$z = -0{\cdot}18$ Not significant		

Table VI. *Age* 16.

		Height			Height	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	24	171·07	1·5	40	170·00	1·2
Cricket	17	170·68	1·8	46	169·20	1·1
Swimming	9	168·73	2·5	20	168·84	1·7
Sprinters	9	168·00	2·5	35	168·29	1·3
Lacrosse	24	167·92	1·5	36	168·12	1·2
Soccer	23	167·72	1·6	56	167·85	1·0
High jump	3	166·47	4·3	18	171·92	1·8
Gym	15	162·66	1·9	26	164·17	1·5
L.D.R.	13	161·65	2·1	35	165·99	1·3
Broad jump	—	—	—	7	170·57	2·8
	$z = 0{\cdot}53$ {5 % point $= 0{\cdot}35$ / 1 % point $= 0{\cdot}49$} Significant			$z = 0{\cdot}38$ {5 % point $= 0{\cdot}33$ / 1 % point $= 0{\cdot}44$} Significant		

		Weight			Weight	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Rugger	24	59·97	1·4	40	59·90	1·1
Swimming	9	58·09	2·3	20	60·03	1·6
Cricket	17	57·59	1·7	46	57·61	1·0
Sprinters	9	56·28	2·3	35	57·42	1·2
Soccer	23	55·97	1·5	56	57·08	1·0
Lacrosse	24	55·29	1·4	36	56·46	1·2
High jump	3	55·07	4·0	18	61·42	1·7
Gym	15	52·47	1·8	26	54·28	1·4
L.D.R.	13	50·63	1·9	35	54·99	1·2
Broad jump	—	—	—	7	59·10	2·7
	$z = 0{\cdot}49$ {5 % point $= 0{\cdot}35$ / 1 % point $= 0{\cdot}49$} Significant			$z = 0{\cdot}49$ {5 % point $= 0{\cdot}33$ / 1 % point $= 0{\cdot}44$} Significant		

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

Table VI. *Age* 16 (continued).

	Those gaining colours or credits in one game only			Those gaining colours or credits in the game mentioned and at least one other		
		Chest			Chest	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Swimming	9	81·99	1·5	20	82·97	1·0
Rugger	24	81·02	0·9	40	81·40	0·7
Cricket	17	80·24	1·1	46	80·68	0·7
Sprinters	9	79·94	1·5	35	80·83	0·8
Gym	15	78·97	1·1	26	79·77	0·9
Soccer	23	78·80	0·9	56	79·94	0·6
High jump	3	78·73	2·6	18	82·61	1·0
Lacrosse	24	77·71	0·9	36	79·01	0·7
L.D.R.	13	77·50	1·2	35	79·43	0·8
Broad jump	—	—	—	7	81·29	1·7
	$z=0{\cdot}26$ {5 % point = 0·35; 1 % point = 0·49}			$z=0{\cdot}40$ {5 % point = 0·33; 1 % point = 0·44}		
	Not significant			Significant		

		Vital Capacity			Vital Capacity	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Sprinters	8	3854	206·5	31	3785	105·4
Rugger	24	3845	119·2	40	3801	92·8
Cricket	17	3684	141·7	44	3661	88·5
Soccer	23	3590	121·8	55	3605	79·1
High jump	3	3497	337·3	17	3795	142·3
Lacrosse	24	3438	119·2	36	3565	97·8
Swimming	8	3416	206·5	19	3620	134·6
Gym	14	3369	156·1	24	3540	119·8
L.D.R.	13	3321	162·0	34	3610	100·6
Broad jump	—	—	—	7	3771	221·8
	$z=0{\cdot}27$ {5 % point = 0·35; 1 % point = 0·49}			$z=-0{\cdot}08$ (5 % point = 0·33)		
	Not significant			Not significant		

		Buoyancy Index			Buoyancy Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Lacrosse	24	543·13	5·7	36	536·75	4·3
Soccer	23	535·52	5·8	56	529·98	3·5
High jump	3	533·33	16·1	18	522·72	6·1
Rugger	24	532·96	5·7	40	530·63	4·1
Sprinters	9	524·44	9·3	35	521·00	4·4
Cricket	17	522·41	6·8	46	521·57	3·8
L.D.R.	13	521·31	7·7	35	523·31	4·4
Gym	15	515·67	7·2	26	516·50	5·1
Swimming	9	512·78	9·3	20	516·00	5·8
Broad jump	—	—	—	7	524·00	9·9
	$z=0{\cdot}36$ {5 % point = 0·35; 1 % point = 0·49}			$z=0{\cdot}35$ {5 % point = 0·33; 1 % point = 0·44}		
	Significant			Significant		

https://doi.org/10.1017/S0022172400018416 Published online by Cambridge University Press

Table VI. *Age* 16 (continued).

	Those gaining colours or credits in one game only			Those gaining colours or credits in the game mentioned and at least one other		
		Respiratory Index			Respiratory Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Sprinters	8	354·88	19·1	31	341·52	6·5
Soccer	23	343·00	11·3	55	335·58	4·9
L.D.R.	13	341·08	15·0	34	344·85	6·2
Rugger	24	339·17	11·1	40	335·70	5·8
Lacrosse	24	336·38	11·1	36	337·61	6·1
High jump	3	336·33	31·2	17	321·76	8·8
Gym	14	334·50	14·5	24	337·46	5·5
Cricket	17	333·24	13·1	44	331·45	7·4
Swimming	8	309·63	19·1	19	314·37	8·4
Broad jump	—	—	—	7	334·57	13·8
	$z = -0·42$ (5 % point $= -0·54$) Not significant			$z = 0·17$ (5 % point $= 0·33$) Not significant		
		Vital Index			Vital Index	
	No. of cases	Mean	S.E.	No. of cases	Mean	S.E.
Sprinters	8	676·63	23·5	31	652·16	12·3
L.D.R.	13	656·69	18·4	34	659·00	11·7
Gym	14	649·00	17·8	24	652·38	13·9
Soccer	23	642·17	13·9	55	633·69	9·2
Cricket	17	639·59	16·1	44	635·64	10·3
Rugger	24	639·58	13·6	40	634·30	10·8
High jump	3	631·67	38·3	17	613·06	16·6
Lacrosse	24	619·46	13·6	36	629·58	11·4
Swimming	8	595·25	23·5	19	606·05	15·7
Broad jump	—	—	—	7	638·71	25·8
	$z = 0·08$ Not significant			$z = 0·18$ (5 % point $= 0·33$) Not significant		

The writer is indebted to Miss Salmon for the care with which she has carried out the laborious task of computing the various statistical constants and to Dr A. Bradford Hill and Dr J. O. Irwin for their patient study and helpful interpretation of the statistical results.

REFERENCES.

BALDWIN, B. I. (1914). *Physical Growth and School Progress.* Washington: United States Bureau of Education.

MUMFORD, A. A. (1911). *First Annual Report of the Medical Officer of the Manchester Grammar School.*

—— (1927). *Healthy Growth.* A study of the relation between mental and physical development. Oxford Univ. Press.

—— (1929). Physique and physical activity in relation to school and university progress. *Ann. Rep. Med. Officers of Schools Assoc. and 17th Ann. Conference of Educational Assoc.*, 29 Gordon Square, London, W.C. 1.

—— (1930). Types of body build and their relation to special aptitudes and capacities. *J. Hygiene,* **30**.

SCHULMAN, H. (1930). *Bulletin of High Schools, New York City.* Board of Education, New York.

(*MS. received for publication* 12. x. 1932.—Ed.)