ANTHROPOMETRIC STUDIES OF GLASGOW SCHOOL CHILDREN.

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(With 2 Graphs.)

The object of the present investigation was to determine the relation between the variations in hair and eye colours and variations of weight and stature; so that one might know what allowances, if any, would be necessary to make for variations of the proportion of children in different classes of hair and eye colour in different age groups and in the two sexes in the different schools under investigation with respect to the factors influencing bodily growth and nutrition. Incidentally, the analysis might reveal racial differentiation if such were present in this population.

The observations were made on children from three elementary schools under the Glasgow School Board by Miss Tully and Dr Weir. Of the 2801 children examined in this part of the study, there were 1362 males and 1439 females in age groups ranging from eight to thirteen.

The observed weights were taken correct to 0·5 lb.; the heights to 0·25 in. in indoor clothes without boots.

The different types of hair were classified in four categories; fair (F.), light brown (L.B.), dark brown (D.B.) and red (R.).

F. includes white, flaxen and golden yellow.
L.B. ,, all shades of brown except dark.
D.B. ,, dark brown and jet black.
R. ,, the various shades of red (light, bright and dark red).

The eye colours were grouped in five categories; light (L.), light medium (L.M.), medium (M.), dark medium (D.M.) and dark (D.).

L. includes light shades of grey.
L.M. ,, blue and bluish grey.
M. ,, pure grey, orange and mixed shades.
D.M. ,, brown and dark brown.
D. ,, black.

Table I shows the means and standard deviations of weights and heights for each age and sex group[1]. The standard deviation, which is a measure of the absolute variability of any quantity, is seen to increase with age in both sexes, and to be higher in females than in males in all age groups in the case

[1] Owing to the heavy expense of printing, it is not possible to reproduce the tabulations from which the statistical constants in the text tables were calculated; but anyone interested can consult the originals on application to the author.

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of weights. The variability in heights is much smaller, and shows no tendency to increase with age or to differ in the sexes.

The coefficient of variation, a somewhat better comparative measure of the variability, which expresses the standard deviation as a percentage of the mean $\frac{(\text{Standard Deviation} \times 100)}{\text{Mean}}$ was then worked out (Table II). This table shows the greater variability of females in comparison with males, and the variability in weights increasing with age; but when taken in relation to the probable errors, the differences observed do not attain to the conventional

Table I.

Males.

Age	Mean weight	Standard deviation	Mean height	Standard deviation	Total
8	50·85	5·46	46·25	2·64	236
9	55·44	6·82	47·77	2·68	232
10	60·55	7·54	49·96	2·66	246
11	65·02	7·46	51·67	2·82	241
12	68·40	8·52	52·71	2·96	204
13	74·99	10·67	54·71	3·32	203

Females.

8	49·48	5·88	46·00	2·41	261
9	53·91	7·00	47·85	2·76	278
10	57·39	7·57	49·57	2·78	246
11	61·29	8·09	51·13	2·66	238
12	69·43	11·43	53·58	2·93	228
13	78·48	12·76	56·00	3·29	188

Table II.

Coefficients of Variation.

	Weights		Heights	
	Males	Females	Males	Females
VIII	10·73±·337	11·88±·356	5·70±·178	5·25±·155
IX	12·29±·391	12·98±·377	5·61±·176	5·76±·165
X	12·45±·384	13·20±·408	5·32±·162	5·61±·171
XI	11·46±·357	13·20±·415	5·45±·168	5·20±·161
XII	12·45±·422	16·46±·534	5·62±·188	5·47±·173
XIII	14·22±·485	16·26±·580	6·06±·204	5·88±·205

standard of significance (3 × probable errors) except in the instances of children of eleven and twelve years of age. The probable error of the difference between two uncorrelated magnitudes is equal to the square root of the sum of the squares of the probable errors of the quantities entering into the difference. Thus (*e.g.*) in children of eight years the difference between the coefficients of variation is (11·88 − 10·73) = 1·15.

The probable error of this difference is $\pm \sqrt{\cdot 11357 + \cdot 12674} = \pm \cdot 490$. The difference is thus 1·15 ± ·490.

Similarly for the other age groups, the differences are in the case of weights as follows:

0·69 ± ·54; 0·75 ± ·56; 1·74 ± ·55; 4·01 ± ·68 and 2·04 ± ·76.

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The observed differences are thus individually insignificant. The general tendency, however, to increase with age is so obvious, and the greater variability of females over males in weights is so constant, that they may well represent a real distinction although it cannot be statistically demonstrated having regard to the size of the probable errors.

The coefficients of variation in stature show no relation to age, and no constant difference between the sexes.

The correlations between height and weight are given in Table III. These, as might be expected, are all high; and there is no material difference in this respect between males and females, or at different ages.

The correlations between hair colour and eye colour were worked out by the product moment (Table IV) and contingency methods. The coefficients are

Table III.

Correlation. Height—weight.

Age	Males	Females
VIII	·9277±·006	·7644±·017
IX	·7522±·019	·7995±·015
X	·6669±·024	·8090±·015
XI	·7349±·020	·7704±·018
XII	·7344±·022	·7280±·021
XIII	·7860±·018	·7827±·019

Table IV.

Correlation. Hair—eye colour.

Age	Males	Females
VIII	·3176±·039	·1718±·041
IX	·2341±·042	·2928±·037
X	·2455±·040	·2144±·041
XI	·3139±·039	·2737±·040
XII	·2469±·044	·4274±·037
XIII	·2202±·045	·3647±·043

all positive; and in view of the comparatively low probable errors, may be taken as significant, although, having regard to the arbitrary assumptions involved, the actual values do not merit much attention[1]. The coefficients are of about the same order of magnitude as found by other writers by different methods. They show, as we should expect, that there is a predominance of the blonde and brunette types over those with the anomalous combinations of dark hair and light eyes and *vice versa*.

On the other hand, the lowness of the correlation indicates a tendency to homogeneity among the Glasgow school children. As pointed out by Tocher[2], if there were two races, one of the blonde and one of the brunette type, present in a population in equal proportions, the correlation between hair and eye colours would approach unity. But the more this population in time and through intermarriage was thoroughly crossed, or the more nearly it came to

[1] It is wholly arbitrary to assume that the differences separating hair-colour or eye-colour groupings can be replaced by a series of quantities and *equal* class units.

[2] *Biometrika*, vol. VI. p. 130.

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consist of members entirely of either class, the smaller would be the value of the correlation, and the nearer would it approach zero. None of the above coefficients are of a high order of magnitude, the mean coefficient for all age and sex groups being ·2769, it is obvious that heterogeneity is not a predominant feature of this population.

Table V shows the correlations between weight and stature and hair and eye colours. The data were first of all treated by determining the product moment coefficients of correlation. The difficulties and risk of fallacy in the application of such a method are obvious, as a quantitative value for any one type of hair or eye colour cannot yet be given from the lack of chemical or other data on the subject; so that it is impossible to group hair and eye colours in such a manner as to indicate measurable increases in the amount of pigment contained therein.

Table V.

Correlations.

Males.

	Weight		Height		
Age	Hair colour	Eye colour	Hair colour	Eye colour	Total
VIII	−·0430±·044	·0750±·044	·0154±·044	·0559±·044	236
IX	·0881±·044	−·0950±·044	·0317±·044	−·0393±·044	232
X	·1142±·042	−·0054±·043	·0760±·043	−·0838±·043	246
XI	·0373±·043	−·0630±·043	·0990±·043	−·0382±·043	241
XII	−·0587±·047	·0216±·047	−·0960±·046	−·0815±·047	204
XIII	·1009±·047	−·0568±·047	·0152±·047	−·1539±·046	203

Females.

VIII	−·0864±·041	·0004±·042	−·1340±·041	−·0262±·042	261
IX	−·0251±·040	−·0839±·040	·0164±·040	−·0215±·040	278
X	−·0351±·043	−·0433±·043	−·0502±·043	−·0296±·043	246
XI	·1680±·042	−·0360±·044	·0497±·044	−·0603±·044	238
XII	·0587±·045	·1220±·044	·0741±·044	·0045±·045	228
XIII	·1925±·047	·0430±·049	·0988±·049	−·0446±·049	188

The tables, however, being so arranged as to indicate increasing pigmentation in each succeeding array, it was thought that this method would demonstrate linear regression, if such were present.

In the case of the relation between weight and hair colour there is evidence of some association amongst the older females. In males no such correlation is seen in any age group.

In both males and females in all age groups there is no demonstrable relationship between weight and eye colour or between stature and hair or eye colours.

It may be concluded, then, that there is no tendency for an increase (or decrease) in weight or stature to accompany an increase (or decrease) in the density of pigmentation in the hair or eyes. The significant coefficient for females in the correlation of weight with hair colour are so small that it is very doubtful if any importance attaches to these isolated observations.

The correlation ratios were then calculated for the relationship between weight and height with hair and eye colours (Table VI). The correlation ratio (η) is a measure of the degree of association between two variables, and

is the best measure when the regression is non-linear. The observed ratios were then corrected by the method suggested by Pearson[1]:

$$\text{corrected } \eta^2 = \frac{\text{observed } \eta^2 - (K-1)/N}{1-(K-2)/N},$$

where K = the number of arrays, and N the number of observations. The correction is made to allow for the influence of the number of arrays. The probable errors were calculated from these corrected values (in brackets). The values of η even when uncorrected for grouping are all very small; when

Table VI.

Correlation ratios.

		Weight		Height	
Sex	Age	Eye colour	Hair colour	Eye colour	Hair colour
Males	VIII	·1448 (·0638±·044)	·1160 (·0274±·044)	·0765	·1152 (·0237±·044)
Females	VIII	·0914	·1371 (·0858±·041)	·0608	·1314 (·0763±·042)
Males	IX	·1313	·0909	·0777	·0277
Females	IX	·1284 (·0461±·040)	·1576 (·1189±·040)	·1718 (·1237±·040)	·1341 (·0851±·040)
Males	X	·0607	·1684 (·1277±·042)	·2451 (·2106±·041)	·1104
Females	X	·1267	·0510	·2050 (·1615±·042)	·0774
Males	XI	·1032	·0617	·0861	·1518 (·1034±·043)
Females	XI	·0824	·1249 (·0550±·044)	·1437 (·0624±·044)	·2294 (·2009±·042)
Males	XII	·0986	·1734 (·1246±·046)	·1105	·1936 (·1517±·046)
Females	XII	·1710 (·1089±·044)	·1039	·0958	·0687
Males	XIII	·0638	·2705 (·2428±·045)	·1614 (·0803±·047)	·2189 (·1829±·046)
Females	XIII	·1013	·2063 (·1640±·048)	·1226	·1832 (·1334±·048)

corrected, some become indeterminate, others are scarcely significant. In a few scattered cases the ratios are significant in relation to the probable errors. It was therefore thought advisable to calculate the mean weights and statures for each array of hair and eye colours; and then to determine if the differences of these from the mean values of the whole were significant. The means are given on Tables VII and VIII. As our criterion of significance we might either take three times the probable error of the difference of the mean value of any one array from the mean of the whole series, or $2\sigma/\sqrt{N}$ (where σ = standard deviation of the whole series; N = the number of observations in any individual array). In this case we have chosen the latter. The mean of the series may be represented by a horizontal line on the graph, and on either side of this are plotted the values of $\pm 2\sigma/\sqrt{N}$ for each type of hair and eye colour.

[1] *Biometrika*, vol. VIII. p. 254.

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The areas so obtained represent the limits of the deviations on either side of the mean which might be expected to occur solely from the influence of random sampling. If the means of the arrays fall within this area, they cannot be safely said to differ significantly from the average. The results are illus-

Table VII.

Males.

	Average heights in relation to eye colour					Average heights in relation to hair colour			
Age	L.	L.M.	M.	D.M.	D.	F.	L.B.	D.B.	R.
VIII	45·96	46·05	46·35	46·58	46·22	45·69	46·29	46·61	43·50
IX	47·68	47·04	47·87	47·87	47·26	47·73	47·75	47·92	48·20
X	50·11	50·36	49·84	49·48	49·88	49·43	49·98	49·77	52·00
XI	52·44	51·44	51·67	51·72	51·50	52·71	51·47	52·56	51·00
XII	53·23	52·50	52·91	52·24	52·32	52·75	52·07	53·23	50·00
XIII	56·33	55·28	54·64	54·61	53·93	56·25	54·52	54·71	59·25

	Average weights in relation to eye colour					Average weights in relation to hair colour			
Age	L.	L.M.	M.	D.M.	D.	F.	L.B.	D.B.	R.
VIII	49·56	50·47	50·92	52·30	49·96	50·23	50·85	51·06	44·00
IX	57·12	55·62	55·13	56·04	53·74	55·53	55·30	56·17	59·40
X	59·53	61·11	60·35	60·48	60·47	55·92	60·81	59·96	65·00
XI	67·11	64·71	65·03	65·64	63·97	62·86	65·15	65·00	69·00
XII	66·68	69·15	68·86	67·30	68·80	67·63	68·45	70·06	61·75
XIII	75·00	76·12	74·98	74·77	73·52	80·88	74·02	75·35	92·75

Table VIII.

Females.

	Average heights in relation to eye colour					Average heights in relation to hair colour			
Age	L.	L.M.	M.	D.M.	D.	F.	L.B.	D.B.	R.
VIII	43·96	46·21	46·03	45·70	46·00	46·39	46·13	45·35	45·56
IX	48·65	48·20	47·36	48·45	47·90	47·07	47·98	47·34	49·33
X	50·89	49·73	48·97	49·69	50·18	50·31	49·52	49·63	49·11
XI	52·00	51·31	50·80	50·93	51·40	50·93	51·04	51·37	51·40
XII	54·00	53·34	53·42	54·09	53·55	53·26	53·49	53·78	54·50
XIII	57·08	56·26	55·78	55·55	56·34	53·83	56·09	56·41	55·50

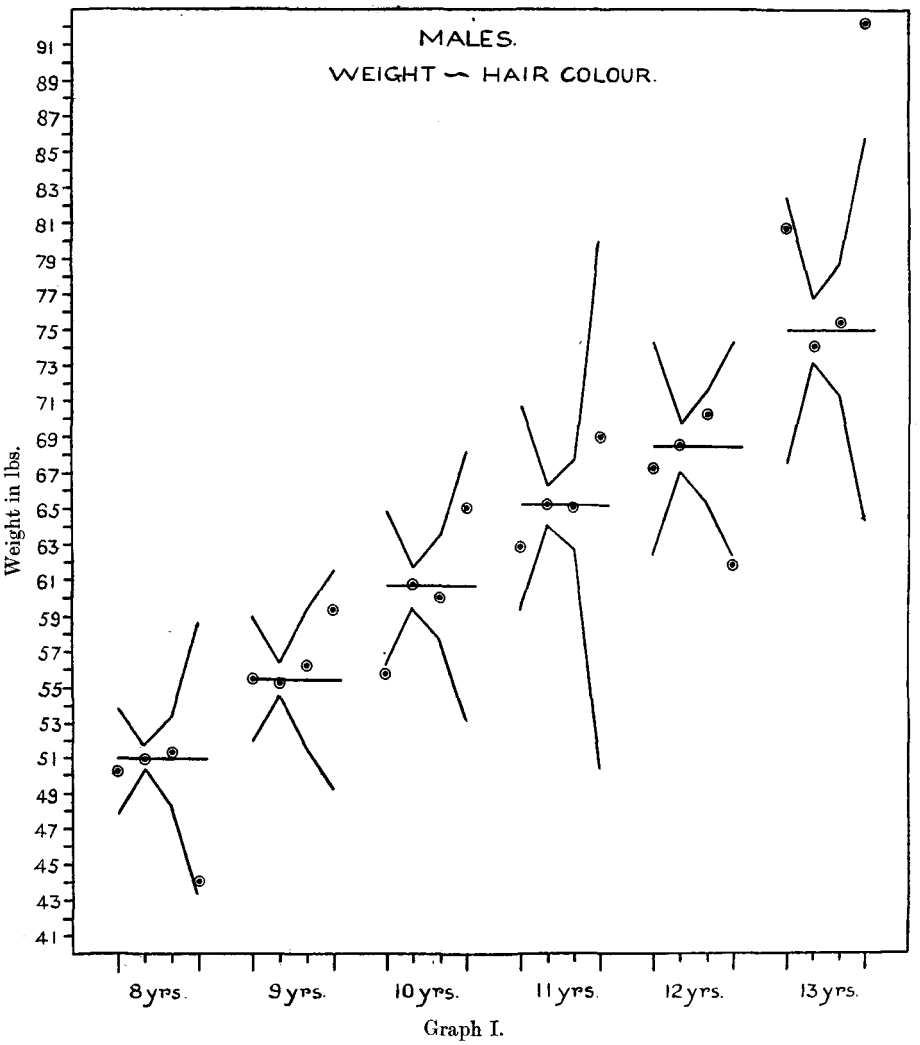
	Average weights in relation to eye colour					Average weights in relation to hair colour			
Age	L.	L.M.	M.	D.M.	D.	F.	L.B.	D.B.	R.
VIII	48·75	50·44	49·93	48·42	49·47	49·94	49·80	47·70	50·44
IX	54·59	54·95	53·55	54·86	52·30	50·40	54·48	49·19	53·00
X	59·21	58·10	56·60	56·45	58·61	57·13	57·61	56·59	57·11
XI	62·71	61·61	60·67	61·07	61·90	57·93	61·45	62·37	62·80
XII	64·72	69·34	68·69	72·12	69·88	65·37	69·34	69·30	71·75
XIII	76·85	81·32	78·57	79·10	80·83	69·42	79·57	80·76	81·20

trated by Graphs I and II. (Space does not permit the reproduction of all the other graphs; but the salient features are noted below.)

In Graph I (Males: Weight—Hair Colour) it is seen that only in three cases does the mean of any array differ sensibly from the average of the whole series. The weight of fair haired children at age 10 is just significantly below the mean. Red haired children at age 12 are below the mean weight; at age 13

they are quite definitely above the mean. At all ages the weights of red-haired children deviate more widely from the general average than do those of any other type.

In none of the cases do the light brown or dark brown haired children differ significantly from the mean.



Graph I.

In the case of female children (Graph II), only two instances overstep the limits placed by $2\sigma/\sqrt{N}$; dark-brown being below the mean at age 9; fair-haired being below the mean at age 12.

Hair colour and stature. Fair-haired females of age 13 are just below the mean; males of 12 with red hair are below, while those of 13 years are well above the average.

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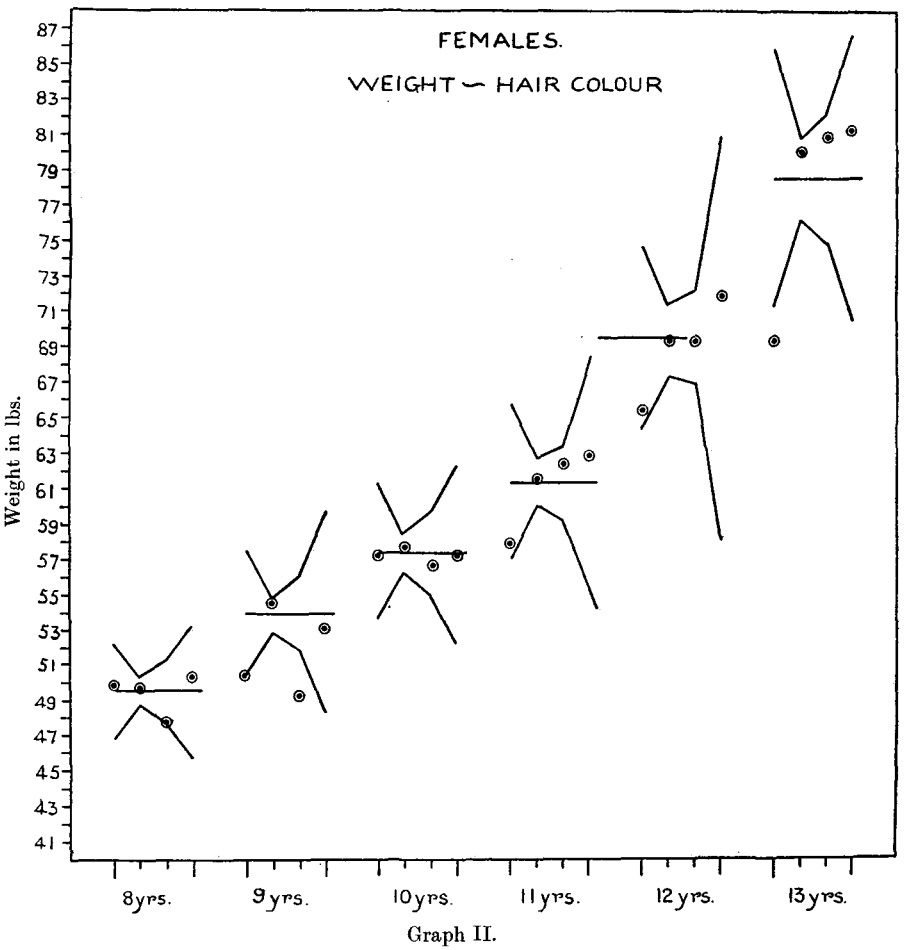
Weight and eye colour. In neither males nor females does the mean of any array differ significantly at any age from the mean of the whole series.

Height—eye colour. Light-eyed females at 8 years are below, at age 10 are above the mean for these ages. In males, none of the groups differ sensibly from the mean.

It would appear, then, that there is no important difference between the weights and statures of any group of hair or eye colour and the general average for the whole age group.



Graph II.

Tables IX and X have been drawn up to show the predominant types of hair and eye colours. They show the percentages of the different categories in the various age and sex groups.

There is a tendency for the percentage of fair-haired children to grow less as age advances, in the case of males. This does not appear to be so in females. The percentage of the light brown type tends also (though irregularly) to

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diminish with age in both sexes. This diminution in fair and light brown is compensated for by the increase in the proportion of darker hair at the later ages. These results confirm the observation that hair tends to darken with age.

The proportion of red hair is extremely small in all age and sex groups, and there is no uniformity in the successive age groups. The number of observations on red-haired children in this material is too small for any reliable conclusions to be drawn from them.

The predominant type of hair in every group is light brown.

Table IX.

Percentage of types of hair colour.

Age	Sex	F.	L.B.	D.B.	R.
VIII	Males	5·51	86·02	7·63	0·84
	Females	6·89	73·18	16·48	3·45
IX	Males	6·47	86·21	5·17	2·15
	Females	5·39	75·54	16·91	2·16
X	Males	4·88	82·93	10·57	1·62
	Females	6·50	73·17	16·67	3·66
XI	Males	2·91	81·74	14·94	0·41
	Females	5·88	66·81	25·21	2·10
XII	Males	3·92	76·96	15·20	3·92
	Females	8·33	57·89	32·02	1·76
XIII	Males	3·94	77·34	16·75	1·97
	Females	6·38	61·17	27·13	5·32

Table X.

Percentages of types of eye colours.

Age	Sex	L.	L.M.	M.	D.M.	D.
VIII	Males	11·44	25·00	35·17	16·95	11·44
	Females	9·19	18·39	45·98	12·64	13·79
IX	Males	10·78	22·41	34·05	19·40	13·36
	Females	6·12	19·78	44·60	15·11	14·39
X	Males	7·72	30·49	32·52	16·26	13·01
	Females	7·72	25·61	38·21	17·07	11·39
XI	Males	7·47	18·67	43·57	16·18	14·11
	Females	10·08	22·69	43·28	11·34	12·61
XII	Males	10·78	12·75	48·04	16·18	12·25
	Females	10·96	17·98	42·10	14·48	14·48
XIII	Males	5·91	12·31	52·22	15·27	14·29
	Females	6·91	16·49	45·74	15·43	15·43

Table X shows that the predominant type of eye colour is that classed as medium. Group L. decreases in a somewhat irregular manner as age increases in the male series. In females there is no such definite trend. Light medium eyes show an increasing number up to the 10th year in both sexes, and then there is a gradual fall.

The proportion of medium eyes is quite definitely greater in older children in the male sex. Dark medium eyes show no definite relationship to age in either sex. Dark eyes are much more common in older than in the younger children. The increase with age, however, is very irregular.

The predominance of the shade of hair classed as L.B., and of eyes classed as M. has been shown by Tocher[1] to be positively correlated with density of population.

From this analysis, it would appear that there is no significant association between weight or stature and hair and eye colours.

The types of hair included under the class light brown are greatly in excess in all ages and sex groups; and there is significant defect in fair and red hair.

Medium eyes are in excess in both sexes at all ages.

The proportion of the lighter shades of hair and eye colours shows a fairly definite tendency to decrease with increasing age, more marked in the case of males than females.

Females are slightly more variable in weights than males; and this variability in weights has a tendency to increase with age.

There is no significant difference in the variability of stature between males and females.

In conclusion I should like to express my indebtedness to Prof. Noël Paton for giving me the opportunity of working out these results and to Dr M. Greenwood for his guidance and assistance in the prosecution of this study.

[1] *Biometrika*, vol. VI. p. 30.

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