THE RELATION OF FINGER-NAIL GROWTH TO NUTRITIONAL STATUS

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In 1937 Le Gros Clark & Buxton made a series of observations on the nail growth of Oxford undergraduates and children from private and elementary schools in Oxford. The series which they examined were intended to serve as a basis for future work and we have followed the technique outlined in their paper. This technique is as follows:

With a small file (of the type employed for opening glass ampoules), a fine transverse scratch was made across the nail at a distance of about 2 mm. from the margin of the lunula. The distance between the proximal margin of the file-mark in the median axis of the nail and the central point of the margin of the lunula was then measured with a Beck's Luminex Magnifier fitted with a micrometer scale. With this instrument it was usually possible to take measurements to within 0·1 mm. After an interval of approximately one month, a second observation was made, in this way recording the displacement distally of the file-mark during this period. The daily growth of the nail could then be calculated. With regard to this technique it may be emphasized that the margin of the lunula provides a fixed base-line, for it marks the edge of the germinal matrix of the nail-bed, which shows quite an abrupt structural transition into the sterile matrix. In the case of the thumb, and the index and middle fingers, the margin is usually sharp enough to allow of accurate measurement without difficulty. In the ring and little fingers the outline is not always so distinct, and considerable care may be required to obtain reliable measurements. In some individuals the lunula may hardly be visible at all in these fingers, and in such cases it was not possible to make an observation. In cases where the margin of the lunula is obscured by a forward extension of the eponychium, it can often be made more apparent by smearing a trace of vaseline over the surface of the nail. The displacement of the file-mark in the course of a month amounted usually to about 3 mm. In some instances of exceptionally rapid growth (e.g. in nail-biters), the mark was found to have disappeared at the free edge of the nail by this time.

In the previous paper it was found that there was no significant difference between right- and left-hand growth, between male and female, or between age groups. Our observations, as will be seen later, confirm this. The authors

also found that there was no significant difference between the growth of the finger nails of undergraduates and of children attending both private and elementary schools.

The individual observations suggested that a more detailed examination of the effect of nutritional status on nail growth should be undertaken, and the results of such an enquiry are embodied in the present paper. It should be stated at the outset that, as the seasonal variation is very considerable, our observations, which were taken in the autumn and winter, are not absolutely comparable with the Oxford figures taken in the spring and summer.

ASSESSMENT OF NUTRITIONAL STATUS

The assessment of the nutrition of the children who are the subject of this investigation was along the lines of the clinical examination which has been the subject of so much criticism lately, and which of itself cannot bear the scrutiny of statistical examination. There is, however, a factor in this investigation which may have eliminated in part the subjective errors which do occur. The children were drawn from three different types of school in the borough of Leytonstone in East London, a technical school, two central schools, and two elementary schools. The elementary schools drew their children from the poorest wards in the district, and as the school staffs were asked to pick out the children whom they knew were from homes where privation was the rule, the task of the assessing officer was, in consequence, less liable to error. Out of the ninety-five elementary school boys who completed the test, seventy-nine were assessed as of C nutrition[1], so that there was substantial agreement between the assessment and what was the probable economic condition of the homes of the children.

The remainder of the A, B, and C nutrition groups attended the central and technical schools. This group of children had been subjected to a routine physical examination a few weeks previously to these tests being made, either by M. L. G. or by another school medical officer, who from previous experience is known to have a very similar standard. The children were reassessed again quickly, and if found not to agree with the previous assessment, the second one was adhered to so that the same standard might prevail throughout. It was found necessary in only nine cases (out of 284) to change the assessment. It cannot be claimed that the three groups do not overlap in any way, since we do not claim infallibility for our clinical acumen where so many have been proved inaccurate before; but with the rough economic test which was applied to the majority of the C group, it seems justifiable to say that that group at least was likely to contain few A's or B's.

[1] The letters A, B, and C denote the grades of nutrition as laid down by the Board of Education for the guidance of school medical officers when making the returns of the state of nutrition in their area. A means excellent, B means normal, and C means subnormal nutrition.

METHOD OF COLLATING OBSERVATIONS

The observations were first reduced to a daily average growth, since it was not possible always to allow the same interval of time between measurements. They were then divided into the following categories within the nutrition groups A, B, and C; normal (that is, those who showed no evidence of nail-biting), nail-biters, and total observations. The sexes were counted separately but subsequently pooled. Le Gros Clark & Buxton, in the paper already referred to, showed that on their data there was a marked distinction between nail-biters and normal, but no significant difference between the sexes. They also found a high correlation between right and left hands. It was considered therefore that one hand would provide a convenient check on the other. The means and standard deviations were then calculated and will be found in Table I. Table I A gives the numbers on which the various constants are based. The discussion which follows will be most easily understood if the table is read downwards.

Table I. *Average daily growth in micromillimetres*

		Right hand			Left hand		
	Class	Normal	Biters	Total	Normal	Biters	Total
				Means			
♂	A	107·21	119·00	110·35	107·86	121·70	111·35
	B	107·12	119·49	109·62	107·23	119·17	109·75
	C	99·71	109·98	100·96	100·69	109·21	102·44
♀	A	106·17	119·47	108·83	105·86	120·17	109·50
	B	104·45	122·10	107·85	100·26	124·10	104·95
	C	101·00	121·00	106·00	94·22	110·33	98·17
♂+♀	A	106·22	119·42	109·98	107·39	121·34	110·25
	B	106·27	119·90	109·07	104·02	120·60	108·21
	C	98·92	111·33	101·54	100·10	109·50	102·10
				Standard deviations			
♂	A	14·19	—	15·72	15·13	—	16·65
	B	16·84	—	18·69	16·10	—	18·42
	C	16·54	—	16·77	20·83	—	20·07
♀	A	20·56	—	20·71	14·29	—	17·42
	B	16·81	—	19·94	19·11	—	22·35
	C	—	—	—	—	—	—
♂+♀	A	15·87	16·59	16·96	14·85	17·82	16·77
	B	16·47	22·69	19·17	17·35	23·78	19·79
	C	15·68	16·70	17·08	19·64	16·00	19·41

Table I A. *Number of cases in each group*

	Normal		Biters		Total	
Class	Male	Female	Male	Female	Male	Female
A	55	18	20	6	75	24
B	90	42	24	10	114	52
C	81	9	21	3	102	12

First, a superficial examination shows that the male means for groups A and B are consistent, and it needs no statistical treatment to affirm their similarity.

Group C appears to be different, and accordingly this difference was reserved for exact statistical treatment. The female means show a gradual diminution from group A to group C, but as the numbers in groups A and C were so few, this might be the result of random sampling. An examination of the "biters" and the totals confirmed the result of the first examination, except that the female nail-biters showed the only actual inconsistencies in the table. However, an examination of the numbers on which they were based amply accounted for this. Both sexes were then pooled. Definitely consistent results were obtained, and the similarity between A and B once more appeared, except that the left hand alone suggested that possibly there was a gradation between the groups even there.

The standard deviations are singularly liable to be affected by random sampling, but an examination of the right hand figures showed a surprisingly close approximation, and there was certainly nothing like the contrast between A and B on the one hand, and C on the other, which appeared in the means. The greatest difference which occurs is between A and C on the left hands of the males. This may be roughly tested as follows. The standard error of the standard deviation is equal to the standard deviation divided by the square root of twice the number of cases. The standard error then of the standard deviation of the males of C group is approximately 2 $(20+\sqrt{(102)})$, but the difference between 20·07 and 16·65 is 3·32, which is less than twice the standard error of the former figure alone, and the difference may reasonably be set down to random sampling. The point is discussed later.

RELATION OF NUTRITIONAL STATUS AND NAIL GROWTH

Having from a superficial examination concluded that A and B groups were similar in the rate of nail growth, it was decided to apply more exact treatment to possible differences between these and C. But since, if there was a difference between B and C, *a fortiori*, there would be a difference between C and A, only the former case has been considered.

A comparison between two means raises certain difficult points in regard to method. Since the standard deviations are so similar, it seemed best to use the following test:

$$\frac{\bar{x}_1-\bar{x}_2}{\sqrt{\left(\frac{\Sigma_1-\Sigma_2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)\right)}},$$

where $\bar{x}_1$ and $\bar{x}_2$ indicate the means compared, Σ the sums of the squares ($S\,(x-\bar{x})^2$ in Fisher's nomenclature), and n_1, n_2 the number of observations in each sample.[1]

The disadvantage of tests between means is, first, that we cannot tell from the test whether the difference, if it appears, is due to a real difference in means

[1] For a discussion on the use of this formula, see *Biometrika*, vol. XXIX, p. 350 (1938).

or to a difference in the variability. It has already been pointed out that the standard deviations are very similar so that this difficulty appears to vanish. The second difficulty, which is inherent in all statistical method, is that the number of cases as well as the measurements come into the formula, and therefore where numbers are few we may not realize the existence of a real difference, while similarly where numbers are great we are possibly inclined to give weight to rather too fine differences. In this particular case, when the sexes were analysed, a difference was found between B and C in the males, but not in the females. This was almost certainly due to the smaller number of females. It was decided therefore, first of all, to take the pooled sexes, and to use the formula already given. The results were as follows:

Comparison	Degrees of freedom	t	
		Right	Left
A and B:			
Normal	203	0·0148	0·985
Total	263	0·734	1·185
B and C:			
Normal	220	3·321	3·397
Total	278	3·366	2·597

Since from Fisher's table, $p=0{\cdot}01$, $t=2{\cdot}750$ with 30 degrees of freedom, $t=2{\cdot}57582$ with ∞ degrees of freedom, we may reasonably conclude that there is no difference between the means of A and B, but there is between those of B and C, thus confirming our decision based on superficial examination. In the case of the biters, the figures for the right hand are 0·0879 between A and B and 1·52 between B and C. This latter figure is not significant, but the difference, if such exists, may be obscured partly by the great variation of the biters and partly by the small number of cases. Applying a similar method to the males alone on the right hand, t for B and C normal is 3·3197, which is certainly significant, and 3·5948 for the total B and C. For the total on the left hand it is 2·7992. On the other hand, for the normal on the left hand the figure falls to 2·331. Even for the normal females, of whom there are only 9 in the C group, the value of t is 2·175, which is equivalent to a p of less than 0·05. This is of doubtful significance, but the doubt is probably due to the lack of numbers rather than to any real lack of difference between the two groups.

Turning to the differences between the standard deviations, we have used Fisher's z test, where z is equal to the difference between the natural logarithms of the two standard deviations compared. Tests were made between the various A and B groups and between the B and C groups. Only one significant difference was found, between the male B and C normal, where $z=0{\cdot}3575\pm0{\cdot}0966$. It will be remembered that there was an irregularity here also in the means. It should, however, be noted that the differences on the right hand between A and B, although not significant, are approaching significance. No conclusion can be reached one way or the other from the present evidence, but possibly further evidence may show that the A group really are, as they appear super-

ficially to be, less variable than the rest. One of us in examining a previous series noticed that in the best nourished persons extreme variations appeared to be less common.

This important point leads to the relation of these averages to the individual. It is clear that we cannot assess a single person by his nail growth. The groups overlap very considerably, as is shown by the graph. It is only when comparatively large numbers are studied that the differences appear.[1]

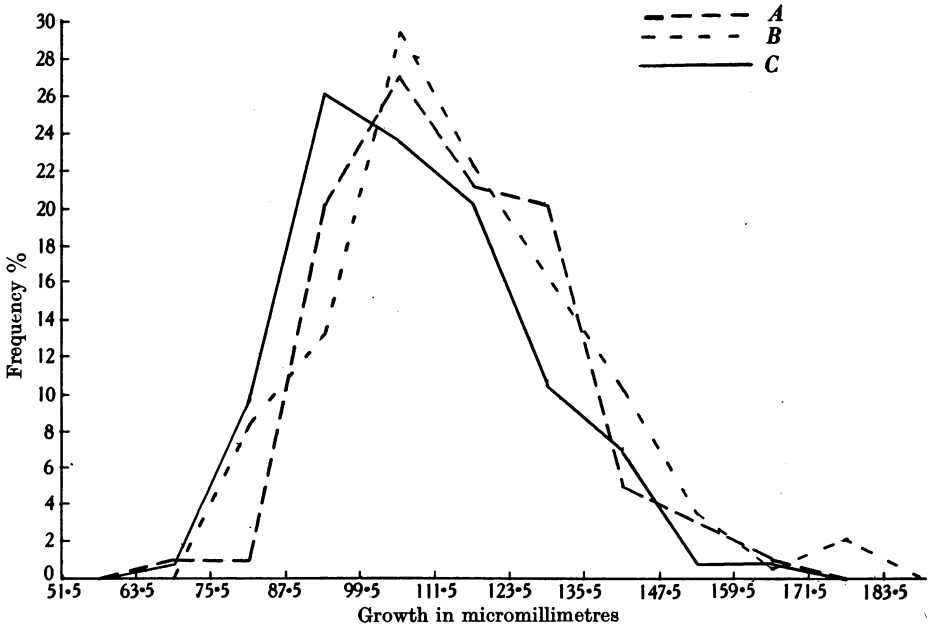

Fig. 1. Shows the percentage frequency of right hand nail growth in the three nutritional groups. The figure is based on all the measurements, and, for this purpose, both sexes and nail-biters and normal children have been included. The absolute data, not reduced to percentages on which the figure is based, are shown in Table II.

A friendly critic has suggested, that in view of what is written above, the analysis of variance would be a more efficient method of approach. The choice of method would appear to rest very largely on the value of the clinical assessment of A and B groups. Using the analysis of variance for right hand normal growth, combining males and females, one gets the following results:

	Sums of squares	Degrees of freedom	Mean variance	Log_ϵ
Between groups	3587·9	2	1743·9	7·4640
Within groups	77689·6	292	266·1	5·5839
			Difference	1·8801

$z = 0{\cdot}9400$

As the value with 2 degrees of freedom and ∞ for the 1% point of z is 0·7636, one need not doubt that the difference in growth between children of different nutritive status is real. The value of z for the left hand normal is 0·6317, which is less than the 1% point but greater than the 5% point. For the nail-biters, the value of z for right and left hand respectively is 0·2055 and 0·3290, neither of which, as in the t test, are significant. These results form an interesting corollary to those which were obtained by the t test.

Table II. *Summarized distribution of average daily growth in micromillimetres of right hands*

A

Midpoint of group	Male		Female		Total
	Normal	Biters	Normal	Biters	
171·5	—	—	—	—	—
159·5	—	1	—	—	1
147·5	1	—	1	1	3
135·5	1	2	1	1	5
123·5	8	9	3	—	20
111·5	13	1	3	4	21
99·5	18	5	3	1	27
87·5	13	1	6	—	20
75·5	—	—	1	—	1
63·5	1	—	—	—	1
Total	55	19	18	7	99

B

Midpoint of group	Male		Female		Total
	Normal	Biters	Normal	Biters	
171·5	—	1	—	1	2
159·5	—	1	—	—	1
147·5	2	2	—	2	6
135·5	8	2	5	2	17
123·5	5	7	6	—	18
111·5	24	5	7	1	37
99·5	29	3	14	3	49
87·5	12	3	6	1	22
75·5	10	—	4	—	14
63·5	—	—	—	—	—
Total	90	24	42	10	166

C

Midpoint of group	Male		Female		Total
	Normal	Biters	Normal	Biters	
171·5	—	—	—	—	—
159·5	1	—	—	—	1
147·5	1	—	—	—	1
135·5	3	3	1	1	8
123·5	6	4	1	1	12
111·5	16	5	2	—	23
99·5	19	5	2	1	27
87·5	24	4	2	—	30
75·5	10	—	1	—	11
63·5	1	—	—	—	1
Total	81	21	9	3	114

SUMMARY

1. The nail growth was examined of a number of children from elementary schools in Leytonstone, East London, who had been independently graded into three groups, A, B and C, according to their nutritional status.

2. The correlation between nail growth and nutritional status has been listed.

3. Considerable individual variation in nail growth was found, but examination of the group means showed that while there was no difference in the rate of nail growth between groups A and B, the nails of poorly nourished children in group C grew more slowly.

4. The evidence suggests that the nail growth of well-nourished children shows less variation than that of the more poorly nourished.

Our thanks are due to Prof. Le Gros Clark for suggesting this line of research and for his assistance, to Dr A. W. Forrest for permission to carry out the work, and to the Head Masters of Leyton Senior Schools, without whose co-operation the data could not have been collected.

REFERENCE

CLARK, W. E. LE GROS & L. H. DUDLEY BUXTON (1938). *Brit. J. Derm.* vol. L, pp. 221–35.