Tuxford's Index of Nutrition: A Convenient Nomogram

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Tuxford's index, first described in 1917, was based on measurements, made in 1909 and 1910, of half a million elementary-school children in various parts of England (Tuxford, 1917). It is the ratio of weight to height graduated by age to allow for the changes which occur in the ratio with age. The index was again described in 1939, and formulae for use with British units were added to the original metric formulae (Tuxford, 1939). In 1942 Tuxford devised a new index to fit the proportions of London school-children as shown by the 1938 measurements (Tuxford, 1942). The new formula for boys is

$$\frac{W}{H} \times \frac{336-m}{270}$$

and for girls

$$\frac{W}{H} \times \frac{308-m}{235},$$

where W is weight in lb., H height in in. and m age in months. There are similar formulae in metric units. The index was devised and the numerical constants in the age factor chosen so that the value of the index for average heights and weights is 1·0 at all ages considered. Children heavier than average for their height and age have an index greater than 1·0, those lighter than average for their height and age an index less than 1·0.

Although simplicity of calculation was one of the objects of the author, the formula is still somewhat tedious to use with a large number of children. We therefore thought that a nomogram, or line chart, from which the values of the index could be read directly, might be welcomed by nutrition workers.

METHOD

The nomogram

The nomogram is shown in Fig. 1. A straight line through the observed height and weight meets the pivot line at the ratio of weight to height. The line is then swung round this point until it passes through the appropriate age, and the point where the line crosses the index line gives the result.

Example. A boy aged 8 years has a height of 40 in. and a weight of 48 lb. A straight line from 40 in. through 48 lb. meets the pivot line at 1·2. A second straight line from 1·2 on the pivot line through 8 years on the boys' scale meets the index line at 1·067. It is not necessary to read the value on the pivot line.

The straight line is best ruled on a piece of transparent material such as celluloid, but a stretched thread will do almost as well.

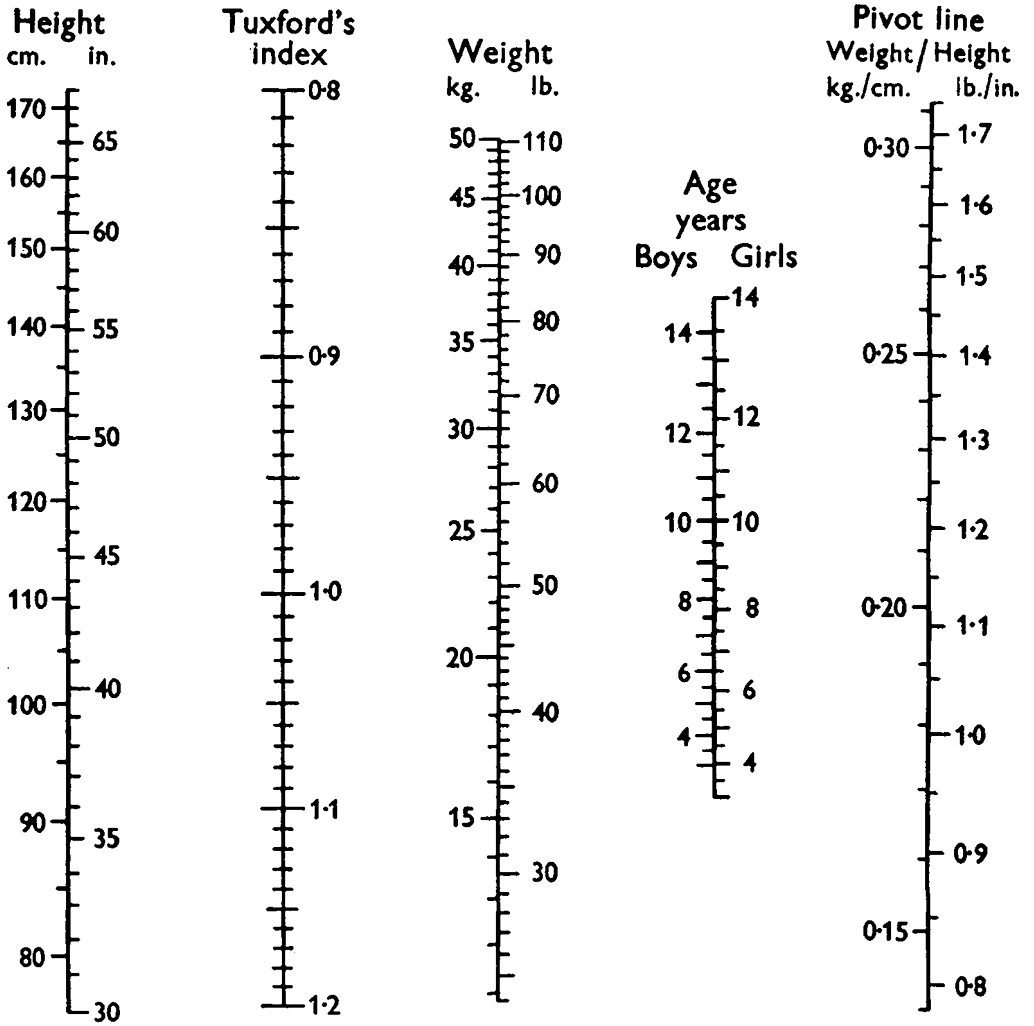

Fig. 1. Nomogram for Tuxford's index. To find Tuxford's index of nutrition, draw a straight line through the observed height and weight to meet the pivot line. Now draw another straight line from this intersection through the appropriate age to meet the index line. The index can be read by interpolation to the third decimal place.

By reversing the process and using the index 1·0 and any two observed values for height, weight and age, it is possible to find the Tuxford 'normal' for the third value quickly. Hence one can evaluate the amount by which a child, or group of children, is over or under the Tuxford 'normal' with respect to height, weight or age.

DISCUSSION

Physical stature at any given age depends on heredity, sex, nutrition and a number of other environmental influences, including the diseases which the child has experienced. To assess the influence of one of these factors it is necessary to eliminate or control the effects of the others, and the main problem is to disentangle the effects of heredity and nutrition. Both affect height and weight, but in different ways. Heredity is responsible for different types of body build, and growth according to these patterns is modified by nutrition. The well-nourished child, if it is also adequately exercised and has no endocrine abnormality, will grow faster and attain adult proportions earlier than the ill-nourished child. That is, limb length will be greater and trunk length less, relative to total height. This change in proportions is associated with a gradual increase in the ratio of weight to height. In undernourishment weight is usually sacrificed earlier and to a greater extent than height. The mere slowing down of growth delays the normal increase in the ratio of weight to height, and the earlier sacrifice of weight still further reduces the ratio and consequently the index. The genetically short child would be of body proportions appropriate to its age. Hence if it were of a height corresponding to a year less than its chronological age it would be expected to be heavy for that height and age.

As an example of how the index reflects subnormal growth, if a child's height and weight were the average for a year less than its chronological age, the index, on account of its age component, would be approximately 0·95. If it were 'retarded' a year in height by genetic difference, the index would be expected to be slightly higher, and if by underfeeding less, than 0·95.

When a poor diet improves, height is usually gained earlier or faster than weight. During this stage, the index may give the false impression of a greater degree of under-nourishment. These defects of the index are, we believe, due to failure of the simple height : weight ratio to make full allowances for the normal changes in development. We believe that it may be possible to devise an index which will more accurately record development, and studies to that end are in progress.

In the meantime, if the index is used to study the physical state of groups of children, individual genetic variations from the average pattern and individual transitional abnormalities due to spurts of growth in height will have relatively little influence on the average indices. The average differences between groups of the same age will be attributable mainly to differences in nutrition. It must be remembered that the present Tuxford index is based on the average heights and weights of London elementary-school children in 1938, which is possibly not a high standard and certainly cannot be regarded as final or ideal. To illustrate what the index does effectively measure with groups of children, we have traced, with the 1938 index, the secular changes in growth in groups of schoolchildren over approximately the last 30 years. For the English boys on whose measurements the original Tuxford index was based, the index is 0·980 at age $3\frac{1}{2}$ and falls steadily to 0·872 at $14\frac{1}{2}$ years. For the girls the corresponding values are 0·998 and 0·853. This decline shows the cumulative effect of continued under-nourishment during school life. London elementary-school children in 1905–12 give the same average index (0·93) as the 1909–10 English children, but the decline with age is less. Since the index is 1·0 at all ages for the 1938 London schoolchildren, it can be said that they were then not only taller at all ages, as the data show they were, but on the average also about 7·5% heavier for their increased heights than children in the period 1905–12. This indicates a substantial improvement in nutrition, greater at higher than at lower ages.

Young (1946) gives average measurements of Glasgow pupils of 5 and 13 years of age for six quinquennial periods from 1910 to 1945. For boys in the younger group the index rises fairly steadily from 0·97 to 0·99; for those in the older group there is a slow rise from 0·87 to 0·91 from the first to the fifth quinquennium, and thereafter a more rapid rise to 0·96 in the last. The indices for the girls are similar. Even in the last and best period, none of the indices reaches the 1938 London standard (1·0). The fact that the index for the 13 year old children is now almost as high as at 5 years old, i.e. that the previous deterioration with age has almost disappeared, taken in conjunction with the time sequence of the changes, suggests that the improvement is related to the provision of first milk, and then milk and meals, in schools. It would be interesting to know how London children now grade with the index of 10 years ago.

There is at present no known satisfactory means of assessing 'state of nutrition'. Jones (1938) demonstrated the unreliability of clinical assessment and, comparing the performance of several 'indices of nutrition', reported favourably on Tuxford's. His results showed that its performance is better with the higher age groups. This would be expected because of the cumulative effects of bad feeding, as illustrated above. The superiority of this index is, we believe, to be attributed solely to the fineness of its graduation by age, by which it does make some allowance for the average change in proportions of the body. On the other hand, with a continuously improving school population, the index in its present form may require frequent revision in order to grade correctly. With children of a higher social class than the London average the age graduation might be different. Children maturing early would probably have a different age graduation from those maturing late. Yet there can be no doubt that the index can be most useful now to follow secular trends; to compare the status of different groups; to select the genuinely undernourished from groups of children and to assess the response to treatment.

SUMMARY

A nomogram for the calculation of Tuxford's index of nutrition is presented. Scales are incorporated both for boys and for girls, using either British or metric units. Reasons for believing it to be an 'index of nutrition', but not the best possible, are discussed.

Enlarged copies of the nomogram can be obtained on application to the authors.

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