Drummond, J. C. (1948). *Practitioner*, **160**, 3.
Durham, M. P., Francis, G. E. C. & Wormall, A. (1946). *Lancet*, **251**, 936.
Dyson, M. & Plaut, G. (1943). *Brit. med. J.* ii, 6.
Ellison, J. B. & Moore, T. (1937). *Biochem. J.* **31**, 165.
Francis, G. E. C. & Wormall, A. (1942). *Lancet*, **242**, 647.
Francis, G. E. C. & Wormall, A. (1944). *St Bart's Hosp. J.* **48**, 99.
Fullerton, H. W., Mair, M. I. & Unsworth, P. (1944). *Brit. med. J.* ii, 373.
Graham, S. G. (1944). *Proc. Nutr. Soc.* **2**, 65.
Haig, C. & Patek, A. J. (1942). *J. Clin. Invest.* **21**, 377.
Hamilton, H. A. & Wright, H. P. (1942). *Lancet*, **243**, 184.
Harris, L. J. (1940). *Lancet*, **239**, 259.
Harris, L. J. (1942). *Lancet*, **242**, 642.
Harris, L. J. (1943). *Lancet*, **244**, 515.
Harris, L. J. & Abbasy, M. K. (1937). *Lancet*, **233**, 1429.
Harris, L. J. & Olliver, M. (1943). *Lancet*, **244**, 454.
Harrison, R. J., Mourant, A. E. & Wormall, A. (1939). *St Bart's Hosp. J.* **46**, 224.
Henley, T. H., Dann, M. & Golden, W. R. C. (1944). *Amer. J. Dis. Child.* **68**, 257.
Hoch, H. & Marrack, J. R. (1948). *J. Obstet. Gynaec.* **55**, 1.
Hynes, M., Ishaq, M. & Morris, T. L. (1946). *Lancet*, **251**, 590.
Josephs, H. W., Baber, M. & Conn, H. (1941). *Johns Hopk. Hosp. Bull.* **68**, 375.
Keys, A., Taylor, H. L., Mickelsen, O. & Henschel, A. (1946). *Science*, **103**, 669.
Kon, S. K. & Mawson, E. H. (1947). *Proc. R. Soc. Med.* **40**, 900.
Leitner, Z. A. & Moore, T. (1946). *Lancet*, **251**, 262.
Lewis, J. M., Bodansky, O. & Haig, C. (1941). *Amer. J. Dis. Child.* **65**, 1129.
Livingston, P. C. (1944). *Lancet*, **247**, 33.
McIntosh, D. G., Moore, T., Keay, D. M. & Cook, R. P. (1946). *Biochem. J.* **40**, 1.
Mackay, H. M. M., Wills, L. & Bingham, K. (1946). *Brit. med. J.* i, 711.
Moore, T. (1937). *Biochem. J.* **31**, 165.
Nelson, C. F. & Stoker, R. (1937). *Folia haemat., Lpz.*, **58**, 313.
Phillips, R. A., Van Slyke, D. D., Dole, V. P., Emerson, K. Jr., Hamilton, P. B. & Archibald, R. M. (1945). *Copper Sulfate Method for Measuring Specific Gravities of Whole Blood and Plasma*. New York: Josiah Macy Jr. Foundation.
Price-Jones, C., Dill, D. B. & Wright, G. P. (1931). *J. Path. Bact.* **34**, 779.
Price-Jones, C., Vaughan, J. M. & Goddard, H. M. (1935). *J. Path. Bact.* **40**, 503.
Robertson, G. W. & Yudkin, J. (1944). *Brit. J. Ophthal.* **27**, 556.
Roscoe, M. H. & Donaldson, G. M. M. (1946). *J. Obstet. Gynaec.* **53**, 431.
Sinclair, H. M. (1942–3). *Proc. R. Soc. Med.* **36**, 80.
Toverud, E. U. & Ender, F. (1936). *Acta paediatr.* **18**, 174.
Wills, L., Mackay, H. M. M., Bingham, K. & Dobbs, R. H. (1942). *J. Hyg., Camb.*, **42**, 505.
Wolff, L. K. (1932). *Lancet*, **223**, 617.
Young, J., King, E. J., Wood, E. & Wootton, I. D. P. (1946). *J. Obstet. Gynaec.* **53**, 251.
Yudkin, J. (1944*a*). *Brit. med. J.* ii, 201.
Yudkin, J. (1944*b*). *Lancet*, **247**, 384.
Yudkin, S. (1941). *Lancet*, **241**, 787.

Anthropometric and Performance Tests

By J. YUDKIN, *King's College of Household and Social Science, Campden Hill Road, London, W.* 8

This paper is less concerned with results of anthropometric and performance tests in determining nutritional states than with the appraisal of the methods used.

Anthropometric measurements

The earliest measurements used were those of height and weight, but many others have gradually been added. As far as children are concerned, it is clear that an allowance has to be made for age. It is evident, however, that even this is not sufficient,

for a child might, for example, be appreciably shorter than the average for his age because of factors genetic rather than environmental. Attempts have been made to allow for such factors by the introduction of various anthropometric indices. Most of these are based on the assumption that environmental factors affect the development of the soft tissues more than that of the skeleton. The commonest indices are those in which the weight is expressed as a function of the height. Other indices relate chest measurement to height, or chest and arm girth to hip width.

Limitations of anthropometric measurements for the nutritional assessment of individuals

In order to determine in how far such measurements assess nutritional states several questions have to be answered.

In the first place, what standards should be adopted to decide whether, for example, the weight, or the weight for age, of a child is normal? The usual course is to determine the average and the range of variation for a large number of apparently normal children. But it is known that such a group will include children who are certainly not normal. The fact that improvements in height and weight have occurred during the last few decades even in the highest social classes shows that we cannot choose any one group of children whose development could be assumed to have reached the maximal level. Again, within the best group there will be a wide range of measurements. What latitude are we to allow for normal biological variations?

Secondly, even if we can decide that a child is poorly developed, how are we to determine the cause? To begin with, we should have to separate hereditary from environmental factors. But, apart from data which we might derive from a knowledge of the parents' stature and build, we have little to help us, and even these data will be of limited value since we should be unable to determine in how far they, too, were conditioned by environmental factors.

Thirdly, even if we could decide that a child is poorly developed and that this is due to environmental factors, how do we separate nutrition—using the term in its restricted sense—from factors such as infection and lack of sleep? This difficulty is a very real one, since inadequate nutrition is most frequently found in association with many of these other factors.

Lastly, are we correct in assuming that inadequate nutrition must necessarily affect the soft tissues proportionately more than the skeleton? Might it not sometimes occur, for example, that both height and weight are decreased in such a way that an index derived on the basis of weight for height is not changed? Observations on Cambridge schoolchildren support this view. Children from a poorer school were, on the average, shorter and lighter than those from a better school but, when the Tuxford index was calculated, it was found that the distribution of the values was exactly similar in the two schools (Yudkin, 1944*a*).

Relation of anthropometric measurements and nutritional state

With all these limitations, it is not surprising that there is no agreement on the best type of measurement or combination of measurements for the adequate assessment of the nutritional state. A satisfactory index based on anthropometric measurements must

show a high degree of correlation with some generally accepted independent method of assessing nutritional state, preferably a clinical one. But it is now well known that the clinical judgement itself is far from being satisfactory. The method used in the School Medical Service may be considered, according to which children are placed in four grades: excellent, normal, fair and poor. One might begin by asking what is meant by excellent; is there then a state of supernormal nutrition? If not, should not all the three grades below this indicate some degree of malnutrition? More important, however, is the fact, so well demonstrated by Jones (1938) and since substantiated by many other workers, that no two clinical observers agree on the classification of a group of children, and, again, that the same observer does not agree with his own classification performed a few days earlier.

Even when the examinations are conducted most carefully by highly trained paediatricians, as in the investigation reported by Jenss & Souther (1940), there is a most distressing lack of agreement between the different observers and between the results obtained at different times by the same observer. For example, less than 40% of the children were placed in the same five grades of nutrition by three different observers.

It must be concluded that the anthropometric data themselves do not give sufficient information about nutritional state and that the accepted methods of clinical assay are unreliable. What is clearly required is an intensive correlative study in a group of children, in which data about the diets, results of clinical and biochemical examination and economical and sociological factors in the lives of the children would be related to the anthropometric data. A similar correlative study might be made of the effect of supplementary feeding on the clinical, biochemical and anthropometric findings. By such studies it might be possible to decide on a criterion of nutritional state and thus to see how anthropometric measurements are dependent on them.

Anthropometric data in the comparative assessment of groups

If sufficiently large groups of children are compared, many of the points of criticism are eliminated. Examples of this method are seen in the comparison of different groups of Cambridge children and of Cambridge and Scottish children (Yudkin, 1944*a*, *b*, *c*, *d*). The only difficulty which arises is the possible existence of genetic differences between the groups.

Static and dynamic nutritional state

A second way in which the measurements may be of value, even in individuals, is in a study of development. If a child progresses at a slower rate than that forecast, e.g. by the Wetzel grid (Wetzel, 1941), it is probable that his nutritional state is declining. It is clear that this method of assessing 'dynamic' nutrition in an individual, like that of assessing 'static' nutrition in a group, has fewer limitations than those described for the study of the 'static' nutrition in an individual. On the other hand, Widdowson & McCance (1944), Friend & Bransby (1947) and others, have drawn attention to the fluctuations in growth at different periods, and it is necessary that steps should be taken to recognize them, or perhaps to minimize them, by extending the observations over a sufficiently long period.

Performance tests

It is known that nutritional deficiency leads to changes in personality, and to decreased performance in physical and psychomotor tests. There appears to be no report of the use of mental or psychomotor tests as a method of assessing nutritional state. There are, however, many reports of the use of physical tests for this purpose. The commonest are those in which a dynamometer is used to determine the strength of grip or of lumbar pull (e.g. Yudkin, 1944*a*, *b*, *c*). In all of these it is essential that psychological factors such as incentive should be recognized and well controlled.

The results of these tests suggest that they can give information of a similar kind to that given by the anthropometric tests. In other words, the performance tests do not say very much about the nutritional state of an individual, but groups can be compared, and changes in groups or individuals allow conclusions to be drawn about changes in nutritional state.

There are few studies of correlation between performance tests and other methods of assessing nutritional state, such as those of Milligan & Lewis-Faning (1942*a*, *b*, *c*, *d*, *e*, *f*) and especially of Jokl and co-workers (e.g. Jokl, 1946). Much more remains to be done before performance tests can be of any great value in assessing nutritional state.

REFERENCES

Friend, G. E. & Bransby, E. R. (1947). *Lancet*, **253**, 677.
Jenss, R. M. & Souther, S. P. (1940). *Publ. U.S. Dep. Labor Child. Bur.* no. 263, p. 121.
Jokl, E. (1946). *Growth*, **10**, 1.
Jones, R. H. (1938). *J.R. statist. Soc.* **101**, 1.
Milligan, E. H. M. & Lewis-Faning, E. (1942*a*). *Med. Offr*, **58**, 77.
Milligan, E. H. M. & Lewis-Faning, E. (1942*b*). *Med. Offr*, **58**, 85.
Milligan, E. H. M. & Lewis-Faning, E. (1942*c*). *Med. Offr*, **58**, 93.
Milligan, E. H. M. & Lewis-Faning, E. (1942*d*). *Med. Offr*, **58**, 101.
Milligan, E. H. M. & Lewis-Faning, E. (1942*e*). *Med. Offr*, **58**, 109.
Milligan, E. H. M. & Lewis-Faning, E. (1942*f*). *Med. Offr*, **58**, 117.
Wetzel, H. C. (1941). *J. Amer. med. Ass.* **116**, 1187.
Widdowson, E. M. & McCance, R. A. (1944). *Lancet*, **247**, 152.
Yudkin, J. (1944*a*). *Brit. med. J.* ii, 201.
Yudkin, J. (1944*b*). *Med. Offr*, **72**, 93.
Yudkin, J. (1944*c*). *Med. Offr*, **72**, 101.
Yudkin, J. (1944*d*). *Lancet*, **247**, 384.

Clinical Surveys and Correlation with Biochemical, Somatometric and Performance Measurements

By H. M. SINCLAIR, *Wellcome Laboratory of Human Nutrition, University of Oxford*

Results given below were obtained by the staff of the Oxford Nutrition Survey, and I am indebted to the former members of the staff for them. But before discussing results we should consider their interpretation and the validity of the methods by which they are obtained.