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SYMPOSIUM ON 'THE ASSESSMENT OF NUTRITIONAL STATUS IN MAN'

Assessment of nutritional intake

By AMANDA M. GRAHAM, *Nutrition and Dietetic Department, Whittington Hospital, Highgate Hill, London N*19 *5NF*

The measurement of habitual food and energy intake in man is one of the hardest tasks a physiologist can undertake. There are three basic problems: firstly, the accurate determination of the subject's customary intake; secondly, the conversion of this information to energy and nutrient intakes; and, thirdly, the length of time food intake should be measured before the information obtained can be said to be a true reflection of habitual food intake. By 'habitual' is meant the food an individual normally consumes to provide the energy and nutrient requirements for his everyday activities (Acheson *et al.* 1980).

One of the most important points is that the objective of any study for which dietary information is desired must be clearly defined. Objectives can include: screening for malnutrition; assessing average intakes to compare with, or estimate, average requirements; or, assessing the normal range of intakes compatible with health.

There are certain features desirable in a dietary survey method (Nelson & Nettleton, 1980):

1. Accuracy of individual measurements
2. Ease of recording
3. The least subject motivation required
4. High co-operation rate in a random sample.

There is no generally accepted method of measuring dietary intake of free-living individuals, but there are three methods most commonly used. These are: dietary recall; weighing and recording of food as eaten; and, the analysis and bomb calorimetry of duplicate meals. This paper will describe each method in turn, with a discussion of the limitations and advantages of each.

Dietary recall

The principle of this method is that food consumed prior to the survey, usually 24 h, is recalled as accurately as possible. A check list of common foods may be used at the end of the study to ensure thoroughness.

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An extension of this is the dietary history method, which is probably the most commonly used technique. This is carried out in four parts (Morgan, 1980).

1. The overall pattern of eating is recorded
2. A 24 h recall of foods actually consumed
3. A cross-check list of common foods
4. Four specific 24 h recorded intakes as a final check.

The advantages of the dietary recall method lie in its simplicity of use and the fact that it is the least time-consuming of the methods considered. However, there are many limitations. The length of interviewing time needed can place a heavy demand on the interviewer. The quantities consumed have to be estimated as they cannot be recorded accurately. Success depends on the subject's memory, communication skills and degree of motivation. The subject must be able to convey estimates of quantity to the interviewer, who often has to be persistent (Acheson *et al.* 1980). Unless days of the week are proportionately represented, a bias could be introduced in estimates of usual intake (Beaton *et al.* 1979). This method does not provide a reliable estimate of the individual intake or a description of the distribution of the usual intake of a population. However, it can provide an estimate of group average intakes (Beaton *et al.* 1979).

The dietary recall method is most useful for small studies with co-operating subjects seen repeatedly, or a single history taken by several hundred subjects for a prospective study (Marr, 1971).

Weighed inventory of food

This is a system of cummulative weighing where each item is weighed before being eaten, and the waste food is also measured. A record is kept of any foods eaten outside the home.

Nutrient intakes are calculated from food intake data tables: for foods not listed, values are obtained from other published data or from manufacturers' information. This method has many advantages (Darke *et al.* 1980, Morgan, 1980). It can be carried out successfully by the subjects themselves with the minimum of supervision. A weighed inventory of food is also fairly accurate, reliable and practical, and has a high degree of reproducibility. Household measures can be used if the utensils are going to be calibrated or standardized values used; this obviously increases subject co-operation (Nelson & Nettleton, 1980). Small representative samples can be surveyed using this method.

It does, however, have some limitations. It can be tedious for some subjects and requires a high degree of motivation if carried out in the subject's normal environment (Acheson *et al.* 1980; Nelson & Nettleton, 1980). It tends to be more biased towards the more numerate and literate people and so may not be a random sample (Nelson & Nettleton, 1980). There may be an alteration in eating habits, because the subject must weigh food, and this could mean the results are not a true reflection of the normal situation. Some loss of accuracy can arise from the subject weighing the food himself, the food tables used for calculation and the fact that only the total cooked weights are recorded for composite or mixed dishes (Marr, 1971).

Despite these limitations, this method is fairly accurate and obtains good co-operation from the subject. It is not as quick to operate as the dietary recall method, but because of its advantages, the weighed inventory method is useful for large-scale surveys (Baird & Schutz, 1980; Darke *et al.* 1980, Sanders & Purves, 1981).

Food tables

These are used for the final analysis of data in the two methods already described. Food tables are average values of the analysis of food samples from various sources and as such have only limited accuracy when applied in any particular case. They are, however, very easy to use and to understand.

For individual nutrients, McCance and Widdowson have found that agreement between analysed values and values given in food tables can be as good as 0·5% (for protein) or as bad as 22% (for fat). This is due to a variation in fat content between samples of the same food (Acheson *et al.* 1980).

Food tables, therefore, provide a source of error in both the dietary recall and weighed inventory methods, but if allowance is made in the final figures, food tables can prove an invaluable tool.

Bomb calorimetry and chemical analysis of duplicate food samples

The subject is asked to prepare duplicate meals where all raw ingredients used in the preparation of dishes are weighed. The method of cooking, weights of cooked dishes, the portion eaten by the individual, waste and any details of brand names are recorded. The duplicate meals as eaten are collected and frozen. The length of time of the study can vary between 24 h and 7 d.

If the samples are subjected to bomb calorimetry this will measure the energy of the meals. The foodstuff is placed in a chamber and ignited; all organic material is burnt and the heat liberated can be measured. Heats of combustion of the three main composites—carbohydrate, fat and protein—are known as the Atwater factors.

Chemical analysis can also be carried out on the sample to determine nutrient composition. Here the energy intake is expressed as kcal calculated from the Atwater values, e.g.

$$\text{fat energy} = 9{\cdot}3 \times \text{fat (g)}$$

$$\text{protein energy} = 4{\cdot}1 \times 6{\cdot}25 \times \text{N (g)}$$

and carbohydrate energy is the difference of the total energy minus protein and fat energies. Chemical analysis can be a very complicated procedure, for example, fat is measured after extraction with chloroform and evaporation, starch and sucrose are measured by the formation of glucose after enzymatic hydrolysis. Minerals and trace elements can also be quantified by chemical analysis, e.g. Na^+ and K^+ are measured with flame photometry (Abdulla *et al.* 1981).

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This method is very accurate and can be used for individuals, not just groups. It can be useful if an individual's intake at a particular time is required. However, the limitations can outweigh the advantages. The duplicate sampling method requires a high degree of motivation from the subject and is very likely to affect normal eating habits. It is time-consuming and tedious because of the complexity of the collection and analysis of the data, and is very costly for the actual data collected. Factors of digestibility and utilization must also be applied to determine net intake of nutrients (Marr, 1971; Acheson *et al.* 1980; Morgan, 1980).

Conclusion

General. Money, time and personnel are frequently the major constraints determining which method is used (Morgan, 1980). The improvement and development of methods are hampered by:

1. Reliance on the quickest and cheapest techniques
2. Negative attitudes towards dietary surveys as tools in the assessment of nutritional status
3. Lack of imagination.

Despite requiring a detailed interview and estimation of quantities consumed, the dietary recall method is very useful for studies of few subjects seen repeatedly, or a single history from a large sample. It is quick, requires relatively little time to analyse and is easy to implement. Dietary recall is very useful when determining dietary intake in a clinical situation, for example, when a large sample must be interviewed in a short time to assess intakes.

The weighed inventory method is less onerous than the duplicate sampling method and can be carried out by the subjects themselves with the minimum of supervision. It is of major value in accurate large-scale epidemiological studies.

The duplicate sampling method is by far the most accurate, but, because of the time and motivation needed to complete it, is suited to small groups of volunteers. It is of most use when an accurate assessment of an individual's intake is needed, for example, in investigative or metabolic research (Marr, 1971).

Assessment of nutritional status. One area where the assessment of nutritional intake can be important is in the clinical situation. It can be discussed in the context of the total nutritional status of an individual. The latter is assessed from information of four types:

1. Dietary history—this may indicate that the diet has been inadequate in total amount, or in one or more nutrients.
2. Anthropometry—this may show the individual is underweight.
3. Clinical examination—this may reveal signs of one of the qualitative forms of malnutrition.
4. Biochemical tests—these show a low concentration of one or more nutrients in the blood or urine.

At the Whittington Hospital, total nutritional assessment is carried out on 'at

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Table 1. *Nutrition chart*

Surname	First names	Sex ....
Date of birth	Diagnosis	Hosp. no. ....
Ward	Height (cms)................	Ideal weight (kg) ....
Date commenced		

Weight (kg)	Blood
Deficit (%)	Hb
Skinfold thickness (mm)	WBC total
% Body fat	Lymphocytes ($1\cdot5$–$3\cdot5\times10^9$/l)
Lean body mass (weight − % body fat)	Prothrombin ratio
Mid-arm muscle circumference	Transferrin (2·0–4·0 g/l)
Input water (ml)	Albumin (36–52 g/l)
Calories (kcal)	Globulin (15–30 g/l)
Nitrogen (g)	Urea (2·5–7·0 mmol/l)
Fat (g)	Na (135–145 mmol/l)
CHO (g)	K (3·6–4·9 mmol/l)
Vitamins	Ca (2·2–2·6 mmol/l)
Trace elements	PO_4 (0·8–1·4 mmol/l)
Na (130–260 mEq)	Glucose (3·0–5·5 mmol/l)
K (50–100 mEq)	Occ. Investigations:
Output fluid	B_{12} (200–960 pg/ml)
Urinary urea (200–500 mmol/24 h)	Folate
Stool no.	Other
Ketones	

risk' patients using the four tests above. We have designed a nutrition chart to assess nutritional status and monitor the patient's progress (Table 1).

The best initial assessment to tell whether a patient is 'at risk' or not, is by using the eye. Obviously if a patient has protruding ribs or other signs of malnutrition, then careful monitoring must take place.

The dietitian carries out a dietary history and monitors nutrient intake. If the patient is eating, a chart is placed on the end of the bed to record all food eaten. The portion sizes are known from standard hospital weights and the nutrients are calculated from food tables. Alternatively, if the patient is being fed enterally or parenterally, the intake can be calculated from the proprietary product data.

For anthropometry, the arm circumference is correctly measured at the midpoint of the upper non-dominant arm, between the acromial process of the scapula and the olecranon process of the ulna. Skinfold thicknesses are taken at four sites—triceps, biceps, subscapular and suprailiac—using calipers. Standard equations are used to calculate percentage body fat (Durnin & Womersley, 1974), mid-arm muscle circumference and lean body mass. Anthropometric measurements provide information about the chronic nutritional state of the patient.

Biochemical data, in particular serum albumin, serum transferrin, haemoglobin, urea and nitrogen balance, provide us with some indication of the current state of protein synthesis in the body. From the initial data a programme for nutritional support can be implemented.

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Table 2. *Protocol for use with a nutrition chart*

Dietitian	
Day 1	All anthropometric measurements to be taken All intake parameters to be assessed
Day 4	All anthropometric measurements
Days 8, 11, 15, 18, 22, etc.	All anthropometric measurements Record all above on chart
House physician	
Day 1	Take blood for all blood tests on chart and any others as indicated Arrange daily urinary ureas while on chart for first 2 weeks. Then once a week in following weeks Put patient on stool chart
Days 8, 15, 22, etc.	Repreat all blood tests except B_{12} and folate (unless abnormal) House physician is responsible for making sure that all results are written on the chart

To ensure continuous monitoring, a protocol has been designed giving the frequency at which measurements are to be taken (Table 2).

Thus the assessment of nutritional intake can be seen in the wider clinical context. Monitoring of the total nutritional status of a patient can help recovery; therefore, the nutrient intake is one important facet of this assessment, whichever method is used.

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