Clinical Review

NUTRITIONAL ASSESSMENT*

MARK L. WAHLQVIST
DELIA M. FLINT

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An abundant food supply has brought with it problems of overnutrition in Australia, but has not precluded problems of undernutrition and, indeed, overnutrition and undernutrition may coexist. "Dysnutrition" accounts for, or is associated with, considerable morbidity and mortality in Australia. Nutritional assessment, therefore, is as important as other components of patient assessment. The approaches to nutritional assessment include: (i) identification of the individual at risk; (ii) eliciting relevant symptoms and signs; (iii) ascertaining the patients' food and nutrition knowledge and beliefs; (iv) establishing recent and remote food intake patterns; (v) anthropometry; and (vi) various laboratory investigations. The early recognition of excessive adiposity is likely to be a valuable contribution to preventive medicine. In hospital practice, the early recognition of protein energy malnutrition is likely to reduce the duration of hospital stay and morbidity and mortality rates.

NUTRITIONAL ASSESSMENT of the individual allows the recognition of energy imbalance, of risk factors for certain nutritionally-related diseases, and of specific nutrient deficiency or excess. In the Australian context, problems of overnutrition and undernutrition are seen side-by-side in society, and also in the one individual.[1-5] For this reason, the concept of "dysnutrition" is useful.

THE NUTRITION PROBLEMS

As in other areas of medicine, recognition of nutritional disorders requires an index of suspicion based on a knowledge of the problems. These problems are as follows.

1. Energy imbalance (obesity; wasting disorders; anorexia nervosa).
2. Nutrient deficiency (water; dietary fibre; vitamins (folic acid, thiamin, vitamin A); minerals (iron, zinc, magnesium); protein; essential fatty acids)).
3. Nutrient excess (alcohol abuse; sucrose (dental caries); sodium; fat)).
4. Risk factors for nutritionally related disorders (obesity (availability of food, eating patterns, psychological factors, physical activity, socioeconomic circumstances); atherosclerotic vascular disease (hypertension, hyperlipidaemia, platelet aggregation); neoplastic disease (alcohol, fat, cholesterol, dietary fibre lack, food preservation techniques); maturity-onset diabetes (obesity); dental caries (sucrose, "snacking")).

Energy Imbalance

Obesity, or energy excess defined as 120% or more of desirable weight, affects about 10% to 30% of adult Australians,[6,7] and 3% to 5% of children.[8] It is readily evaluated, is more amenable to correction the earlier it is appreciated, and yet is frequently ignored in clinical practice. Early detection could be expected to reduce the prevalence of cardiovascular, neoplastic, diabetic, biliary tract, osteoarthritic, psychological, accident-related and other illnesses.[9-11]

An energy deficit can be incurred during illness because of an increase in requirements. The basal metabolic rate (BMR) is about 90 kJ (22 kcal per kJ) per kg body weight.[12] The additional energy requirement for most patients who are in bed is 30%, for patients who are up and about, 50%, for rebuilding, 80%, and for fever, 10% per degree Celsius.[13] The basal metabolic rate can be calculated according to the Harris-Benedict equation.[14]

Men: $J = 4.2\ (66.473 + 13.7516W + 5.0033H - 6.7550A)$

Women: $J = 4.2\ (655.0955 + 9.5634W + 1.8496H - 4.6756A)$

J=total kilojoules in 24 hours; W=weight in kg; H=height in cm; and A=age in years.

Risk Factors for Nutritionally Related Disorders

The relationship between atherosclerotic vascular disease and diet, and its implications for preventive medicine, are regularly reviewed by the National Heart Foundation of Australia.[15] More recent has been the focus on the nutritional risk factors for neoplastic disease, especially that of alimentary tract, breast, uterus, and lung.[16-19] The role of sucrose, of different sucrose-containing products, and of "snacking" in the pathogenesis of dental caries in Australia is well documented.[4,20]

Inappropriate Nutrient Intake

Protein undernutrition has been thought of as peculiar to underdeveloped countries and the realization of its existence, even in the face of obesity, in Australian hospitals has been slow.[1,3] Dietary fibre deficiency, and its role in areas of human health beyond the gastrointestinal tract, are now appreciated.[21] Australia has a dry climate, and there has been a tendency towards the intake of sweetened carbonated beverages, fruit juices and alcoholic beverages in preference to water to quench thirst. It is of interest that Australia has the third-highest prevalence of urinary calculi,[22] which might be less of a problem if more water were drunk. Folic acid deficiency is probably the most common vitamin deficiency in Australia affecting the socio-economically deprived, the elderly, and alcohol abusers.[23] Night blindness may be seen in alcohol abusers because of reduced dietary intake of vitamin A, reduced retinol mobilization from the liver or reduced conversion to retinal in the eye.[24-26] Food which is rich in carotenoids may also be protective against lung, uterine, and prostatic tumours.[16-18] Zinc deficiency may arise through poor intake, use of certain medications, or alcohol abuse.[27] Essential fatty acids of the ω6 series (linoleic acid) are now more plentiful in the Australian diet supplied by vegetable oils,[28] but there is growing awareness of the importance of the ω3 series (eicosapentaenoic acid) from marine sources.[29]

GROUPS VULNERABLE TO UNDERNUTRITION

At particular risk of undernutrition are the groups shown as follows.

1. Selected age groups (children, adolescents, women in reproductive age, elderly).
2. Specific situations (single persons, single parents, institutionalized persons).

Mark L. Wahlqvist, B.Med.Sc., M.D., B.S. (Adel.), M.D. (Uppsala), F.R.A.C.P., is Professor of Human Nutrition, Department of Human Nutrition, Deakin University, and Delia M. Flint, M.Sc. (Lond.), Cert.Diet., is Lecturer in Human Nutrition, Deakin University, and Consultant Physician, Endocrine Unit, Prince Henry's Hospital, Melbourne.

* Prepared by request.

Address for reprints: Professor M. L. Wahlqvist, Department of Human Nutrition, Deakin University, Geelong, Vic. 3217.

3. Lifestyle problems (physically inactive, alcohol abusers, cigarette smokers).

4. Socioeconomically disadvantaged (limited education, Aborigines).

5. Iatrogenic (medications, surgery).

6. Other medical problems (obesity, wasting diseases).

7. Food faddism.

The clinical history must explore the contributory factors for each vulnerable group.

In hospital practice, protein energy malnutrition (PEM) is the most likely nutritional problem to emerge because of dependence on nutritional support systems preoperatively or in intensive care. Wasting diseases with reversible nutritional components include neoplastic disease, gastrointestinal disease (fistulae, malabsorption syndromes, bowel obstruction), burns, mental and neurological disabilities, chronic renal failure, cardiac and respiratory failure. PEM may manifest as underweight (less than 90% of desirable weight for height), gross underweight when the appearance may be increasingly marasmic or cachectic (less than 80% of desirable weight for height), kwashiorkor (serum albumin concentration less than 28 g/L) or marasmic kwashiorkor (loss of body mass, and serum albumin concentration less than 28 g/L).

The obese are at risk of undernutrition either because of a preference for energy-dense rather than nutrient-dense foods or because of periods of food restriction to energy intakes of less than 5.04 MJ/day (1200 kcal/day) when an adequate intake from ordinary foods is difficult.

Approaches to Assessment

At-risk Individual

Identification of the individual at risk is the first task in nutrition assessment.

Symptoms and Signs

Symptoms and signs of nutrient excess or deficiency must be elicited.[30,31] The clinical features of nutritional deficiency are listed as follows.

Energy: lethargy; reduced fatty tissue; muscle wasting.

Protein: muscle wasting; oedema; hair which is depigmented, dull and easily plucked; leuconychia; parotid enlargement; hepatomegaly (fatty liver).

Vitamins

Thiamin (B_1): high-output cardiac failure ("wet beriberi"); peripheral neuropathy; Wernicke's encephalopathy; Korsakoff's psychosis.

Riboflavin (B_2): angular stomatitis; cheilosis; glossitis; blepharitis; corneal vascularization; scrotal or vulvar dermatosis.

Niacin: pellagra; glossitis; mental disorders; diarrhoea.

Pyridoxine (B_6): peripheral neuropathy; encephalopathy.

Vitamin B_{12}: features of anaemia; mild icterus; peripheral neuropathy; subacute combined degeneration of spinal cord; optic neuritis; mental disturbance.

Folic acid: features of anaemia; leucopenia and/or thrombocytopenia; glossitis; diarrhoea.

Ascorbic acid (C): petechiae; purpura; perifollicular haemorrhage; swollen bleeding gums; corkscrew hairs; bone pain in children; delayed wound healing.

Vitamin A: impaired dark adaptation; xerophthalmia; Bitot's spots; follicular keratosis.

Vitamin D: Rickets; osteomalacia.

Vitamin E: Anaemia.

Vitamin K: Abnormal bleeding.

Minerals

Iron: features of anaemia; angular stomatitis; koilonychia.

Iodine: goitre.

Calcium: rickets; osteomalacia; tetany; convulsions.

Phosphorus: weakness; osteomalacia.

Magnesium: weakness; tetany; convulsions; mental disturbance; cardiac arrhythmias.

Zinc: growth retardation; hypogonadism; impaired taste and smell; delayed wound healing; impaired dark adaptation.

Essential fatty acids: xerosis; anaemia; disorders of platelet aggregation.

Dietary fibre: functional bowel disorders; constipation; haemorrhoids.

A systematic examination of all regions of the body is essential. In examining the head and neck, factors influencing mastication including dentition should be remembered.

Food Intake

In the clinical setting, a dietary history[33] will generally be the food intake methodology used. A food frequency check list[34] of items which are important nutrient sources in the Australian diet could be useful (Table 1). The aim would be to identify recent and remote eating patterns and nutrient intake. Food intake data can be validated by reference to urinary nitrogen output.[35] If there is reason to suspect a particular nutrient deficiency or excess, foods with this nutrient, or known to affect the availability of this nutrient, will need particular attention. In general, an estimate of the average daily intake of a nutrient is made with the aid of food composition tables.[36-38] This is then compared with the recommended daily allowance for this nutrient.[39,40]

Anthropometry

Anthropometry is used to develop an index of adiposity and of lean body mass. For a given height, it has been found that the body weight associated with the best life expectancy is about 90% of the average weight of North Americans,[41,42] and this weight is known as the desirable, or ideal, body weight. Comparable values are to be found in the NHMRC of Australia *Standard*

TABLE 1

*Examples of Food Frequency Check List**

Food Item	Amount	Number of Times	
		Daily	Weekly
Bacon	1 rasher	—	2
Eggs	1	—	3
Milk	2 glasses	1	7
Bread (wholemeal)	4 slices	1	7
Orange	1	—	4
Roast lamb	90 g	—	2
Butter	2 dessertspoons	1	7
Green vegetable	½ cup	1	7
Yellow vegetable	2 tablespoons	1	7
Potato	2 tablespoons	1	7

* Specify the amount and number of times the following foods are eaten daily and weekly.

Knowledge, Understanding and Beliefs About Food and Nutrition

With contemporary Australian nutrition problems, the most important principles for individuals to understand are *(a)* the need to have as wide a variety of foods as possible so that nutrient intake will be adequate and the likelihood of particular excesses minimal; *(b)* food preparation and storage to minimize nutrient loss and avoid bacterial contamination; *(c)* the energy density of foods (for example, red meat is energy-dense and salad vegetables are not), and the concepts of energy balance (food intake and physical activity); *(d)* the nutrient density of foods, so that when physical activity is low, foods of high nutrient density can be chosen; and *(e)* the risks of alcohol abuse. The dietary guidelines recommended by an Australian working party reflect these principles.[32]

Height/Weight Tables of 1957.[43] After growth has ceased, there is no good reason why weight should increase further, so that weight between ages of 20 and 24 years is often taken as an approximation of desirable body weight for an individual. The proportions of excess of, or deficiency in, adiposity relative to body weight between ages of 20 and 24 years are listed as follows.

Obesity	>120%
Overweight	111% to 120%
Underweight	80% to 89%
Grossly underweight	<80%

From Metropolitan Life Insurance Company of New York data of 1959, it was recommended that weight be kept in the range of that between the ages of 20 to 24 years for optimal health. Since frame size is difficult to assess, the average 20 to 24 year old weight for height ± 10% is taken as the acceptable range (Table 2).

TABLE 2
*Average Weights for Men and Women Aged 20 to 24 Years and Over (Indoor Clothing)**

Men		Women	
Height Without Shoes (cm)	Weight ±10% (kg)	Height Without Shoes (cm)	Weight ±10% (kg)
154.5	55.9	142	45.9
157.5	57.5	145	47.1
160.5	58.9	147	48.4
162.5	60.2	150	49.8
165.5	61.8	152	51.2
167.5	63.6	155	52.5
170.5	65.7	158	54.1
172.5	67.5	160	55.7
175.5	69.3	163	57.7
177.5	71.3	176	59.5
180.5	73.4	168	61.3
182.5	75.4	170	63.1
185.5	77.4	173	65.0
187.5	79.7	175	66.8
190.5	82.0	178	68.6

* Adapted from the *Statistical Bulletin, Metropolitan Life Insurance Company,* 1959, 40: November-December.

Uncertainty about excess adiposity arises in the range of 11% to 120%, especially for athletes and persons who are engaged in heavy manual work. In a recent study of 47 top-grade Australian Rules football players, we found that 96% were "overweight" and none was "obese" by the above criteria, and yet skinfold thicknesses showed them to have a subnormal abount of adipose tissue (Inge *et alii*, unpublished data). Thus, confidence that there is excess adipose tissue can be had only where relative body weight is in excess of 120% for 20 to 24 year old persons, or where some other measurement of adiposity is made.

The best index of adiposity will be poorly correlated with height, because muscle and bone mass will increase more predictably in relation to height.[4,4] In this way, the body mass index (BMI=weight (kg)/height $(m)^2$) was developed.[9,10] A BMI of greater than 30 indicates obesity, and is associated with excess mortality. The normal limits for males are 20 to 25 and for females 19 to 24.

In elderly people who have survived to 70 years of age or more, the relationship between weight and height does not have the same significance as a predictor of life expectancy, since it is the survivors who are under consideration. The anthropometric data of 72 elderly Australian women (height and weight) aged 70 years and over are listed as follows.*

145 cm	57.3 ±2.8 kg (*n*=9)
147 cm	57.4 ±3.6 kg (*n*=10)
150 cm	53.2 ±3.7 kg (*n*=10)
152 cm	55.2 ±3.4 kg (*n*=11)
155 cm	56.9 ±3.9 kg (*n*=7)
158 cm	57.7 ±3.6 kg (*n*=10)
160 cm	65.1 ±3.5 kg (*n*=8)
163 cm	63.5 ±2.2 kg (*n*=7)

* Data have only been presented where there were at least six individuals for each height category. Means ±SEM are shown. There were insufficient men in institutions studied to allow data to be presented.

Nevertheless, changes in this relationship in the one individual can be an index of changing health status. Height in the elderly can be difficult to assess because of kyphosis, being invalid, or because of amputation. Weight can be difficult to record in those with restricted movements, or can be influenced more often by fluid accumulation than in younger persons. Thus, alternative indices of adiposity are desirable in the elderly. It appears that, to monitor an individual, the serial measurement of abdominal girth,[4,5] or of mid-upper arm circumference (MUAC) can be useful

TABLE 3
*Possible Indices of Adiposity in Institutionalized Elderly Australians**

	Height		BMI	
	Men (*n*=21)	Women (*n*=63)	Men (*n*=21)	Women (*n*=63)
Abdominal girth	0.14 (NS)	0.18	0.70‡	0.68‡
MUAC	0.29 (NS)	0.21†	0.62‡	0.75‡
Mid-triceps skinfold ..	0.20 (NS)	0.07 (NS)	0.35 (NS)	0.44‡
Subscapular skinfold ..	0.48†	−0.03 (NS)	0.23 (NS)	0.58‡

* Flint, D. M., Wahlqvist, M. L., Parish, A. E., and Smith, T. L. (unpublished data).
Significance of correlation coefficient is indicated by NS ($P>0.05$); † ($P<0.05$); and ‡ ($P<0.001$).
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alternatives; both measurements correlate poorly with height and correlate well with BMI in elderly Australians (Table 3).

Whatever the starting weight, a recent weight loss of 10% or more of usual body weight identifies an at-risk patient. If the loss occurred in less than two weeks, it would more likely be a change in fluid balance, but if it occurred over several weeks it could be due to a loss of adipose tissue and lean body mass.[46]

When weight loss occurs, it is important to distinguish loss in adipose tissue from loss of muscle. The combination of skinfold thickness and arm circumference measurements allows the distinction. Both triceps skinfold thickness and MUAC are measured at the midpoint between the acromial process of the scapula and the olecranon process of the ulna. The mean of the two closest readings of triplicates should be taken for the skinfold thickness. Arm muscle circumference can be calculated as follows:

Arm muscle circumference = arm circumference (cm) − [0.314 × triceps skinfold (mm)]

Standards for triceps skinfold, arm circumference and arm muscle circumference according to WHO[47] are shown in Table 4.

TABLE 4
*Skinfold, Arm Circumference Standards, and Muscle Circumference for Adults**

	Standard	90% Standard	80% Standard	70% Standard	60% Standard
Triceps skinfold (mm)					
Male	12.5	11.3	10.0	8.8	7.5
Female	16.5	14.9	13.2	11.6	9.0
Arm circumference (cm)					
Male	29.3	26.3	23.4	20.5	17.6
Female	28.5	25.7	22.8	20.0	17.1
Muscle circumference (cm)					
Male	25.3	22.8	20.2	17.7	15.2
Female	23.2	20.9	18.6	16.2	13.9

* From Jelliffe, D. B.[47]

Although Harpenden and Lange skinfold calipers have traditionally been used,[47] cheaper plastic McGraw calipers are available and, for the trained observer, yield comparable results.[48] An insertion tape is probably preferable for circumference measurement.[49]

Laboratory Investigations

Another way to assess muscle mass is to measure the 24-hour creatinine excretion per cm height. Normal ranges for men are 82 µmol to 98 µmol creatinine/cm body height, and for women, 56 µmol to 68 µmol creatinine/cm body height. This assessment is said to be of "somatic protein".[50 51]

An assessment of "visceral protein" which includes enzymes, plasma proteins and antibodies can also be made (Table 5). A fall in lymphocyte count can also indicate a decline in visceral protein status.[51]

The state of protein nutrition can further be assessed by the nitrogen balance method which requires an assessment of oral, enteral or parenteral amino acid intake and urinary urea nitrogen output.

$$\text{Nitrogen balance} = \frac{\text{(protein intake)}}{6.25} - \text{(urinary urea nitrogen} + 4)$$

The factor 4 allows for urinary non-urea nitrogen as well as faecal and dermal nitrogen loss.[52]

Amongst the more helpful assays for particular micronutrient deficiencies would be those for the vitamins thiamin, pyridoxine, folic acid, vitamin B_{12},[53] ascorbic acid,[54] carotene,[55] and retinol,[19 56] and for the minerals iron, zinc and magnesium.[57 58] Clues to folic acid, vitamin B_{12} and iron deficiencies are of course, frequently found from haemoglobin determination and blood film.

Immune status is often compromised in malnutrition,[59 60] and, therefore, the assessment of cell-mediated immunity by way of delayed hypersensitivity skin reactions has been recommended to establish whether or not energy exists. However, skin-test antigens, apart from purified protein derivative (PPD), are not always readily available, and not always in a standardized form.

TABLE 5
*Assessment of Visceral Protein**

	Mild	Moderate	Severe
Serum albumin (g/L)	30 to 35	25 to 29	<25
Lymphocytes (cells × 10^9/L)	1.5 to 1.8	0.9 to 1.49	<0.9

* From Kaminski, M. Y., and Winborn, A. L.[61]

Implications for Management

The most important potential contribution of nutritional assessment to human health is in preventive medicine where risk factor profiles can be developed. However, this applies not only in the community and in regard to the major health problems of obesity, cardiovascular and neoplastic disease, but also in reduction of hospital morbidity and mortality. There is increasing evidence that early recognition of protein energy malnutrition in hospitals, especially preoperatively, with institution of appropriate nutritional support can lead to improved survival.[62-67] Also for those cancer patients in whom chemotherapy and/or radiotherapy is warranted, nutritional surveillance and support may be of value.[65]

The Nutrition Care Team

Awareness, assessment and support of the patient at nutritional risk depends on the collective efforts of nursing, dietetic and medical staff members. Nurses are usually in the best position to monitor appetite, food intake, nutrient losses and body weight. Dietitians have special knowledge of food and its relation to disease as well as of anthropometric techniques. The doctor must coordinate the over-all nutritional care with other aspects of management.

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