THE PHYSIOLOGICAL BASES OF THE ASSESSMENT OF NUTRITIONAL STATUS

G. BEDOGNI**, N. BATTISTINI*, S. SEVERI, A. BORGHI**
*Cattedra di Nutrizione Umana, Dipartimento di Scienze Biomediche - Università di Modena;
**Dipartimento di Medicina Interna - Università di Modena

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Introduction

Nutritional status (NS) results from the intake, absorption and utilisation of nutrients (fig. 1).

As nutrients are the building blocks of the body and provide the energy for its work, a close relationship exists between NS and health status (fig. 2).

Macronutrients (proteins, lipids and carbohydrates) have energetic and structural functions while micronutrients (vitamins and minerals) have structural or regulatory functions only (tab. 1).

Although water is not generally regarded as a nutrient, it makes up the most part of the cell and is the medium in which metabolic reactions occur. The assessment of hydration status has therefore to be considered an integral part of the evaluation of NS (1).

Assessment of nutritional status

An integrated view

The relationships depicted in fig. 1 and 2 provide a physiological basis for the assessment of NS in clinical practice. Based on fig. 1, nutritional status can be evaluated through the assessment of the intake, absorption and utilisation of nutrients. This latter, as shown in fig. 2, can be evaluated through the assessment of body composition, energy balance and body functions.

Of the three components of NS (fig. 1), utilisation is the first to be evaluated in clinical practice. Through clinical examination the physician gets an idea of how nutrients are util-
Table 1. - Functions of nutrients.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Energetic</th>
<th>Structural or Regulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>4 Kcal/g; act as energetic substrates only during starvation</td>
<td>e.g. membrane-bound proteins</td>
</tr>
<tr>
<td>Lipids</td>
<td>9 Kcal/g can be stored in great quantities as fat</td>
<td>e.g. lipid bilayer of cell membrane</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>4 Kcal/g; stored in limited quantity as glycogen</td>
<td>e.g. glycocalix</td>
</tr>
<tr>
<td>Vitamins</td>
<td>-</td>
<td>e.g. cell growth (retinoids) and energy metabolism (thiamine)</td>
</tr>
<tr>
<td>Minerals</td>
<td>-</td>
<td>e.g. bone mass (calcium) and energy metabolism (magnesium)</td>
</tr>
</tbody>
</table>

Table 2. - Clinical evaluation of nutritional status. The patient suffered from an intestinal subocclusion due to Crohn's disease (observation of authors).

<table>
<thead>
<tr>
<th>Intake</th>
<th>History</th>
<th>Physical Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal appetite; reduced food intake, because of intestinal cramps</td>
<td>The patient was underweight (BMI = 18)</td>
</tr>
<tr>
<td>Absorption</td>
<td>8-10 episodes of diarrhoea every day, accompanied by intestinal pain, especially after meals</td>
<td>Palpable (intestinal) mass in the right lower quadrant of the abdomen</td>
</tr>
<tr>
<td>Utilisation</td>
<td>Weight loss of 4 kg in the last month</td>
<td>Reduced subcutaneous fat</td>
</tr>
</tbody>
</table>

Clinical evaluation

As pointed out above, clinical evaluation (history and physical examination) is an essential part of the assessment of NS. In many cases, it allows an assessment of the three components of NS (tab. 2).

The "subjective" assessment of NS allowed by clinical evaluation has an accuracy which is often comparable to that achieved by more "objective" methods (3).

However, a patient who needs nutritional support has clearly to undergo a more complete assessment of NS (4).

Assessment of body composition

The study of body composition is based on the subdivision of body weight (Wt) in two or more compartments (5). The 2-compartment model separates Wt into fat mass (FM) and fat-free mass (FFM). According to the 4-compartment model, FFM comprises water, proteins, minerals and glycogen (fig. 3).

It is well known that FM and its distribution influence the risk of disease (6). However, there is increasing evidence that the composition ("quality") of FFM is more important in determining this risk (7, 8). This is not surprising if one considers the metabolic significance of FFM, as discussed in the next section on energy balance.

For reasons of cost and availability, the clinical assessment of body composition is performed mainly by indirect techniques.

The measurement of skinfolds should always be included in the evaluation of NS because of its low cost and clinical significance (9) (tab. 3).

Bioelectric impedance analysis (BIA) appears to have the potential to be employed for the assessment of hydration status in ill subjects at a population level (10-13).

Dual-energy X-ray Absorptiometry (DXA),
Fig. 3. - The 2- and 4-compartment models of body composition in the reference man. Wt = weight; FFM = fat-free mass; FM = fat mass; TBW = total body water; PM = protein mass; MM = mineral mass; Gn = glycogen.

which provides the most accurate assessment of bone mass available to date, is being validated against multi-compartment models of body composition to assess its role for the assessment of soft-tissues (14, 15).

Assessment of energy balance

Energy balance represents the difference between energy intake and energy expenditure. In the clinical field, energy intake is most commonly measured by 24-h dietary recalls. However, recalls of 7 days or more are needed to have energy estimates that are enough accu-

rate for practical use (16, 17). A detailed description of the techniques available for the assessment of food intake is given elsewhere (18).

The main components of total energy expenditure (TEE) are basal energy expenditure (BEE), the thermic effect of food (TEF), physical activity (ACT) and, in paediatric age, growth (GRW):

\[
\text{TEE} = \text{BEE} + \text{TEF} + \text{ACT} + \text{GRW}
\]

In the clinical field, TEE can be measured by the dilution of doubly-labelled water (\(^{18}\)O). However, this technique is expensive and difficult to perform so that its use is restricted to few centres. BEE and ACT can be measured by indirect calorimetry, a technique which also evaluates the energetic substrates in use by the patient (19).

TEE is governed by the body cell mass (BCM), a functional compartment which summarises the metabolic activities of all the cells of the body. Since the adipocyte has a lower metabolic activity with respect to the other cells of the body, BCM is sometimes used as a synonym of FFM. However, BCM cannot be measured directly, contrarily to FFM. The measurement of total body potassium (a ion virtually restricted to the intracellular space), intracellular water and TEE provides nonetheless a characterisation of BCM (1).

Assessment of body functions

To perform its functions, the body relies on the continuous renewal of its mass and on the supply of energy (fig. 2). However, some functions depend more than others on the supply of specific nutrients.

A functional test estimates the levels of a nutrient by measuring a function that depends on it. For example, the rapid dark adaptation test is highly sensitive (95%) and specific (91%) for the emeralopy caused by vitamin A deficiency (20). The measurement of circulating retinoids is instead an example of biochemical test (21). This type of test measures the levels of a nutrient in a biologic material assuming that these reflect its body (or organ-specific) stores.

Functional and biochemical tests represent
the so-called “laboratory evaluation” of NS (22). These tests, which may reveal early stages of nutrient deficiencies, are however of difficult interpretation when they are not performed in the context of a complete evaluation of NS (fig. 2). For example, the levels of circulating retinoids may be reduced for a variety of reasons: protein-energy malnutrition, low-fat diets, chronic liver disease, cystic fibrosis, chronic infections, etc.

**The assessment of nutritional status in clinical practice**

Despite the general agreement that NS is a major determinant of health status (23), physicians seem to give little attention to NS of their patients. A recent study found evidence of malnutrition in 40% of patients on admission to hospital; the nutritional status of patients declined during their hospital stay, and this deterioration was most marked in those who were initially malnourished (24). The fact that this lack of attention to nutritional problems was first detected about 20 years ago (25) suggests that the substantial progresses made by nutrition research have not been paralleled by their clinical application.

**Conclusions**

NS is a major determinant of health status and its assessment has the potential to improve the clinical management of patients with a variety of diseases. We hope that the simple organisation of nutritional assessment offered by this paper will help physicians to reach this important goal.

**Summary**

This article offers an organisation of nutritional assessment based on the relationship between nutritional status and health status. In particular, it suggests that the assessment of nutritional status should be performed through the evaluation of energy balance, body composition and body functions.
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