Physical and Clinical Assessment of Nutrition Status

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3

Physical and Clinical Assessment of Nutrition Status

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I INTRODUCTION

Physical assessment of nutrition status provides data, simply stated, about the size, shape, integrity, and function of the body. Physical assessment includes physical examination and anthropometric measurements, which can be combined with other components of clinical assessment (Table 3.1) to assess body weight, the presence or risk of protein-energy malnutrition (PEM), micronutrient deficiency or excess, health problems predisposing to nutritional problems, and functional status. Physical assessment alone may be used for nutrition screening, which can be defined as the use of a simple test to determine the need for further detailed assessment or intervention. For example, body mass index (BMI) and weight change are commonly used to screen for PEM. Nutrition assessment, defined as a more detailed evaluation of existing status and future nutrition risk, often includes several additional components of clinical assessment that can be synthesized to inform a plan for intervention or future rescreening [1].

The settings in which physical assessment is conducted vary considerably. Anthropometric measures are used extensively in clinical practice, population screening, and research to assess growth and prevalence of underweight or overweight and to estimate disease risk. Findings on physical examination provide evidence for morbidity related to underweight or overweight and may indicate manifestations of micronutrient deficiency or excess. Furthermore, physical assessment variables are used extensively in research to appropriately analyze data, such as the adjustment of resting energy expenditure for body weight or fat-free mass (FFM).

Clinical assessment and particularly physical assessment are commonly perceived as methods to detect malnutrition. This most often denotes PEM. As the understanding of PEM in the settings of starvation and disease has evolved, additional definitions for malnutrition have been proposed for use in clinical settings in which inflammation may play a role in compromising nutritional status. Starvation-related malnutrition occurs when there is chronic starvation without inflammation. Chronic disease-related malnutrition is present when inflammation is chronic and of a mild to moderate degree. Acute disease- or injury-related malnutrition is present when inflammation is acute and of a severe degree [2].

II COMPONENTS OF CLINICAL ASSESSMENT

The type and number of clinical assessment components, as described in Table 3.1, can be tailored to specific settings, purposes, and populations.

A Medical History and the Nutrition-Oriented Review of Systems

The medical history addresses details of the present complaint or illness, body weight change, and the past medical history. An additional nutritionally oriented review of systems (ROS) should be performed to elicit relevant factors not directly related to the present illness. The nutritionally oriented ROS should address the spectrum of behaviors and physiological functions necessary to maintain adequate nutritional status,

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TABLE 3.1 Components of Clinical Assessment of Nutrition Status

Component	Examples
History	Current and past health
	Weight change
	Medications and dietary supplements
	Nutrition-oriented review of systems
	Alcohol, tobacco and illicit drug use
	Family health history
	Social history
Diet	Ability to shop and prepare food
	Appetite and taste changes
	24-Hour diet recall
	Food diaries
	Food preferences
	Food sensitivities
Anthropometrics	Weight
	Height
	Weight for height
	Skinfold thickness
	Circumferences
Physical examination	See Table 3.3
Functional assessment	Handgrip strength
	Activities of daily living
	Walking
Laboratory	Blood and urine tests
	Dual X-ray absorptiometry

including appetite and thirst, and the abilities to procure, prepare, ingest, swallow, digest, and absorb food. For example, poor dental health or use of dentures may predispose to reduced nutrient intake [3], but identification of this problem may be missed without direct questioning. Potential for abnormal nutrient losses, such as from vomiting or diarrhea, and factors that may alter protein, energy, or micronutrient requirements should be addressed.

Medications, including prescription and over-the-counter medications, vitamin and mineral supplements, and herbal preparations should be reviewed. More than 50% of the U.S. population reports use of at least one vitamin, mineral, or dietary supplement [4], but many do not consider nutritional supplements to be medications and direct questioning may be necessary to elicit this history. Medications interfere with nutritional status by multiple mechanisms, including alterations in intake, absorption, and metabolism. Conversely, nutrition status can alter drug bioavailability and metabolism. Table 3.2 describes the mechanisms and potential effect of drug–nutrient interactions.

B Anthropometric Assessment

Anthropometric measurements quantify physical characteristics such as height, weight, weight as a function of height, circumference of body parts, and skinfold thickness. Assessment of these parameters allows comparison to population norms or to values collected over time in the same individual.

1 Height

Measurement of height is necessary to calculate BMI, body surface area, and waist-to-height ratio. When possible, height should be directly measured by a stadiometer. In infants, height, or more accurately length, is best measured by use of a length board [5]. Height begins to decline at approximately age 30 years for both men and women, and this decline accelerates with age; in one longitudinal series, between the ages of 30 and 80 years, women lost 8 cm and men lost 5 cm [6]. Height decreases as a result of vertebral bone loss as well as thinning of intervertebral disks and weight-bearing cartilage. Height may also decrease due to vertebral compression fractures in the settings of osteoporosis or trauma. Loss of vertebral mass and disk compression may induce kyphosis (curvature with backward convexity of the spine), which will further reduce measured height.

When height cannot be accurately measured, such as in acutely ill or immobilized patients, alternatives include self-reported height, estimated height, or surrogate anthropometric measures. Self-reported height is less accurate than measured height because men tend to overreport and women tend to underreport [7]. Self-reported height is more accurate, however, than estimation of height by visualization of supine patients, which has been found to overestimate height [8]. Accuracy of visual estimation of height was better for taller patients compared to shorter patients, possibly because taller patients were closer to the length of the beds in which they were lying, which provided a frame of reference for estimation [7].

Surrogate measures for height include arm span, knee height, and seated height. Use of knee height or arm span to estimate vertical height may be useful in clinical as well as research situations for individuals who cannot stand, who are debilitated, or who have experienced loss of height [6,9]. These measures correlate with vertical height but are influenced less by

TABLE 3.2 Effect of Drugs on Nutrition Status and Nutrients

Drug effect	Effect on nutrition status
Increased or decreased intake and weight gain	Weight gain or loss
Altered nutrient partitioning	Gains in fat mass
Alteration in taste or smell	Reduced interest in food consumption
Dry mouth	Dysphagia
Increased or decreased gastrointestinal motility	Food aversion or reduced intake
Nausea and vomiting	Food aversion or reduced intake
	Dehydration
	Nutrient losses
Diarrhea	Food aversion or reduced intake
	Dehydration
	Nutrient losses
Reduced nutrient bioavailability due to binding or altered transporter function	Impaired absorption of nutrients
Altered nutrient distribution	Altered tissue concentration of nutrients
Altered nutrient function	Altered conversion to active nutrient form Interference with nutrient function
Increased or decreased nutrient catabolism	Nutrient deficiency or excess
Altered excretion due to antagonism or modulation	Nutrient deficiency or excess

age-related changes in stature and impediments to the measurement of vertical height such as disability or frailty [9–12]. Surrogates of height have been used to predict both current height and previous adult maximal height. Arm span, which is the entire distance from the tip of the middle finger of one hand to the other, can be measured with arms stretched at right angles to the body by measuring tape crossing in front of the clavicles. Demi-arm span (the distance from the sternal notch to the tip of the middle finger of one hand) can also be measured and then doubled to calculate arm span. Knee height is best measured with specialized calipers and is performed either in sitting or recumbent positions, making this useful in most ambulatory and hospital settings. Prediction equations for the estimation of height from anthropometric surrogates can then be applied for specific age, gender, racial, and ethnic groups. In several trials that directly compared measured height to surrogates, disagreement between measured height and surrogates increased when the measurement was conducted in ill patients instead of healthy subjects; in these trials, compared to measured height, mean differences were 0–2 cm for self-reported height, −0.6 to4 cm for knee height, and 0–7 cm for arm span [13–16].

2 *Weight*

Ideally, body weight should be measured by use of calibrated beam-type or electronic scales. Alternatives are home scales, calibrated bed scales, chair scales, or wheelchair scales. To monitor changes in weight over time, the use of the same scale is recommended given variability between scales. In cases in which a person cannot be weighed or provide a self-reported weight, weight may be estimated, an inaccurate practice that does, however, improve with experience [8]. Self-reported weights are often inaccurate. Overweight women and men tend to underestimate weight, whereas lower weight men tend to overestimate [7]. In one study, use of a single self-reported weight prevented identification of weight loss in approximately one-third of patients who had lost weight [17].

Technological advances now allow automatic remote monitoring of home scales via telephone or the Internet, a method gaining popularity for management of chronic diseases such as congestive heart failure (in which rapid changes are likely due to body water) and obesity.

Involuntary loss of body weight in the setting of illness is associated with increased risk of morbidity and mortality [18–21]. In hospitalized patients with

a variety of gastrointestinal, infectious, and neoplastic diseases, PEM at admission was associated with an approximately twofold risk of subsequent complications [22]. Involuntary weight loss may better predict risk for PEM-related complications in contrast to a single static measure of weight [20,23,24]. In patients with cancer who were undergoing chemotherapy, a loss of 5% or more of usual body weight was associated with impaired functional status and significantly decreased median survival compared to patients without weight loss [18]. More than 70 years ago, Studley [21] recognized that unintentional weight loss of 20% or more of usual body weight before surgery for peptic ulcer significantly increased the risk of postoperative mortality. Others have confirmed that PEM preceding surgery increases risk of postoperative complications [20,24,25]. Patients who have lost 10–20% of initial body weight over 6 months and have associated physiological defects or those who have lost 20% or more over 6 months should be considered at high risk [26,27].

In obese persons, "adjusted body weight" is used by some to estimate the metabolically active proportion of excess weight. Proposed in 1984 [28], adjustment of body weight reflects the average contribution to weight gain in obesity of 75% fat and 25% FFM: Adjusted weight = ideal body weight + [(actual weight−ideal weight) × 0.25]. There is, however, little empiric evidence to support use of this calculation despite its logical appeal [29].

Precipitous changes in weight are commonly due to alterations in body water with conditions such as congestive heart failure, cirrhosis, and renal failure or with treatments for these conditions such as diuretics.

3 Weight for Height

Weight is expressed as a function of height to facilitate comparison of individuals of varied heights. Historically, ideal body weight or desirable body weight was defined by actuarial data of weight for height with adjustment for frame size. These data have limited applicability to more current diverse populations (compared to those from which original data were obtained) and those with a longer life span [30]. Frame size can be determined by measurement of elbow or wrist breadth or of wrist circumference, which requires the use of specialized calipers or measuring tape. Percentage of ideal body weight was previously used to classify underweight and overweight, and today it is still utilized by some for these purposes or to estimate energy needs, drug dosing, or eligibility for bariatric surgery.

Body weight expressed as a function of height takes the general form weight/height^x and is called body mass index. Whereas x may be any number, Quetelet's index, or kilograms per square meter, has become synonymous with BMI. The use of BMI to assess weight for height in individuals reflects recommendations of the National Institutes of Health and World Health Organization [31].

BMI correlates with body fat for populations, but there remains considerable variation in body composition among individuals at each level of BMI. BMI may be elevated despite relatively low levels of body fat in those with edema or in bodybuilders. The relationship between BMI and body fat differs between sexes, varies among racial and ethnic groups, and also changes over the life span [32]. A single BMI classification scheme for the entire adult age range does not reflect the loss of FFM and gain in fat mass (FM) that accompany aging. Gallagher *et al*. [33] demonstrated that older (> 65 years) men and women have a higher percentage of body fat compared to younger counterparts with the same BMI. Gender is also an important consideration because women have a higher percentage of body fat compared to men of the same BMI [33]. Despite these potential problems, BMI remains an easily calculated and useful method of classifying weight relative to height, especially for populations. In individuals, BMI can be used as one of several indicators of nutritional status with consideration of physical examination and other findings that may alter the expected BMI–body composition relationship.

Both low and high BMI correlate with morbidity and mortality, although there is ongoing debate regarding issues such as the magnitude of risk for those with BMI in the overweight range (25–30 kg/m^2) and how age modifies risk for morbidity and mortality [34–38]. Low levels of BMI, with underweight classified as BMI < 17.5 kg/m^2, are associated with lethargy, diminished work productivity in adults, and multiple health risks [37]. The lowest average survivable BMI, as derived from observations in starvation, famine, anorexia nervosa, or by theoretical models, has been estimated to be 12 or 13 kg/m^2 [39]. However, when weight loss is rapid or associated with illness, morbidity and mortality can occur at any level of BMI.

Obesity has deleterious effects on every organ system as well as quality of life and productivity, and the health effects of obesity are discussed in detail in this volume and elsewhere [38]. Of note, a significant proportion of weight-related co-morbidities, such as type 2 diabetes or obstructive sleep apnea, remain undiagnosed in obese persons [40,41]; this should be kept in mind when assessing obese patients.

4 Body Fat Distribution

Central distribution of body fat increases risk for type 2 diabetes, metabolic syndrome, hypertension, and coronary heart disease [42–44]. Central obesity is a predictor of risk independent of BMI. In some

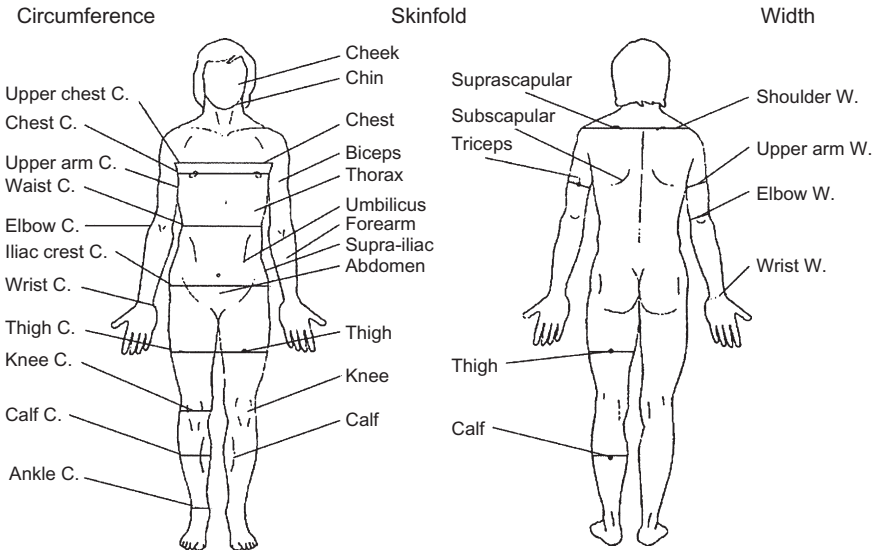

FIGURE 3.1 Landmarks for assessment of waist circumference. *Reprinted from The Obesity Education Initiative Expert Panel on the Identification Evaluation and Treatment of Overweight and Obesity in Adults (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report*. Obes. Res. ***6*** *(Suppl. 2), 51S–209S.*

investigations, when compared to BMI, central obesity has been a better predictor of disease risk [44]. Abdominal adipose depots include visceral, retroperitoneal, and subcutaneous compartments. Measures of central adiposity include a single circumference or waist-to-hip ratio. Current guidelines recommend that abdominal adiposity be assessed by waist circumference measured at the level of the top of the iliac crest [31]. Like BMI, the relationship between anthropometric measures of central obesity and disease risk varies with sex, age, and race [43]. Central obesity generally increases with increasing BMI, making the use of a single cutoff for waist circumference for the entire range of BMI problematic. The need for BMI-specific cutoffs, especially for BMI in ranges less than 30 kg/m^2, has been proposed [43].

Waist-to-height ratio (WHR) has been proposed as an alternate method to evaluate central adiposity. Like waist circumference, WHR correlates well with abdominal fat content. As with BMI, expressing waist circumference as a function of height allows comparison across varying heights. A systemic review conducted by Browning *et al*. [45] confirmed the utility of WHR as a predictor of coronary heart disease and type 2 diabetes. WHR has been found to be accurate in children and adults, men and women, and across ethnic groups. The authors suggest a cutoff of 0.5 as an indicator of risk.

5 Circumferences and Skinfold Thickness Measurements

Circumferences of the trunk or limbs reflect amounts of underlying FFM and FM. Skinfold thickness describes the amount of subcutaneous fat when the skin is pinched by specialized calipers (Figure 3.1). Combinations of circumference and skinfold thickness measurements are utilized to predict body composition and have been validated with comparison to reference measures hydrodensitometry, dual-energy X-ray absorptiometry (DXA), or computed axial tomography [46,47]. The sites at which these measurements are conducted are illustrated in Figure 3.2. Single-site measurements may provide data regarding changes over time in the same individual but are seldom used to predict body FM or FFM.

Circumferences and skinfold thickness may be influenced by several factors, including age, sex, race, and state of hydration [48]. Prediction equations specific to the individual or population should be used when possible. Most reference data have been developed in healthy populations. Use in ill patients is problematic due to frequent body water alterations and due to uncertain effects of some disease states on body composition changes. Measurements obtained in reduced-obese persons who have lost large amounts of weight are likely influenced by redundant skin and persistent alterations in body water distribution [49].

III BODY COMPOSITION ASSESSMENT

Body composition describes and quantifies various compartments within the body. Fat content of the body is expressed as a percentage of total body mass or as absolute FM. Body composition can be assessed at the level of the body as a whole (e.g., weight or BMI); by division into FFM and FM; by division into molecules such as water, protein, and fat; or at an atomic level into elements such as carbon and potassium (Figure 3.3). Methods to assess body composition vary by the compartments being measured. Some commonly employed methods include DXA, which can

divide the body into fat, fat-free, and bone compartments, and density methods such as air displacement plethysmography (ADP; using a device known as the BOD POD) and hydrostatic weighing or underwater weighing and dilution methods that measure body water. These methods utilize body density, body volume, and weight to estimate fat and fat-free compartments. Hydrostatic weighing was the traditional gold standard but has been replaced by ADP and DXA. Bioelectrical impedance (BIA) measures body water, from which FFM can be estimated. The primary use for DXA on a clinical basis is to provide a measure of bone density in order to assess osteoporosis risk, but measures of fat and FFM are not clinically available. Of the methods discussed, BIA is the least accurate for individuals, but due to its ease of use and the low expense of some devices, it has become popular in weight loss programs and health clubs.

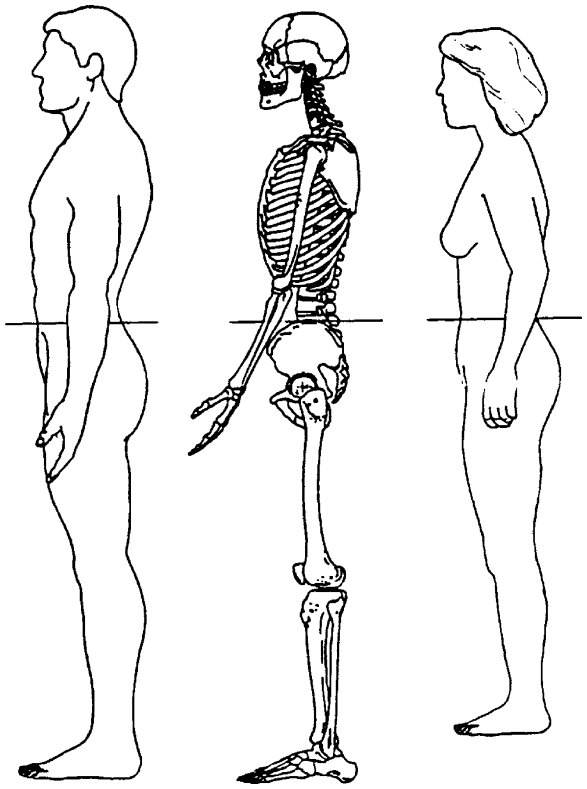

FIGURE 3.2 Body sites for measurement of circumferences, skinfold thickness, and widths. *From Wang, J., Thornton, J.C., Kolesnik, S., and Pierson, R.N., Jr. (2000). Anthropometry in body composition: An overview.* Ann. N.Y. Acad. Sci. ***904***, *317–326. Used with permission of Wiley-Blackwell.*

Although excess adiposity is associated with disease in virtually every organ system, no universally agreed upon criteria for excess body fat has been accepted. The fat mass index (FMI; calculated as fat mass/height^2) has been proposed as a useful measure of adiposity that is independent of FFM. FMI has been validated by comparison to body composition techniques as well as BMI in NHANES [50], but its utility as a measure to predict health outcomes awaits further investigation.

IV PHYSICAL MANIFESTATIONS OF MALNUTRITION

Physical examination may reveal manifestations of malnutrition, but there is limited sensitivity for

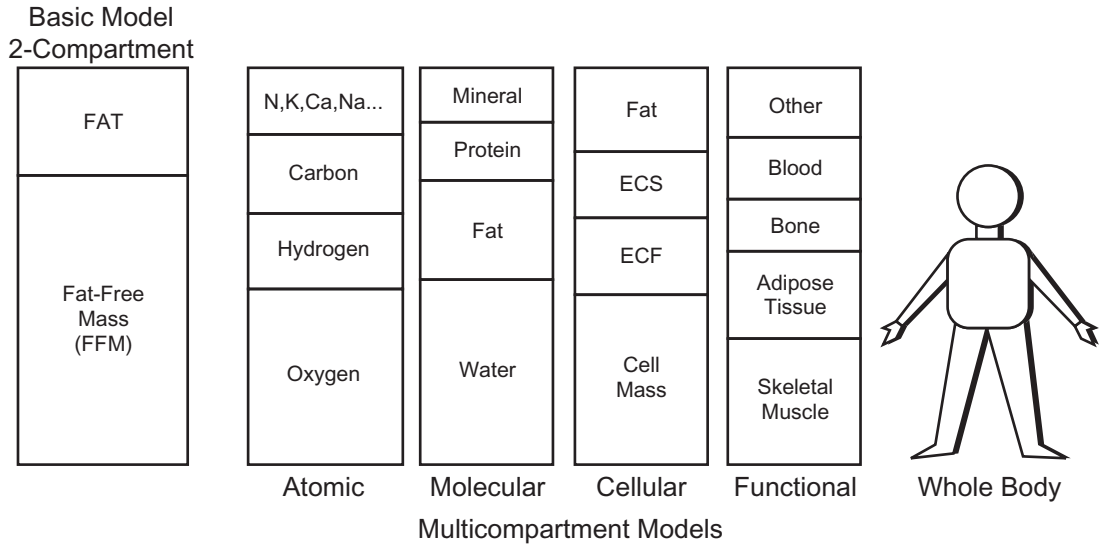

FIGURE 3.3 Models of body composition compartments. ECF, extracellular fluid; ECS, extracellular solid. *From Ellis, K.J. (2000). Human body composition:* In vivo *methods.* Physiol. Rev. ***80***, *649–680. Used with permission.*

micronutrient disorders because these findings may not be clearly manifest until late in the course of deficiency or excess. The specificity of physical examination is limited because deficiencies of several micronutrients may result in similar manifestations (e.g., glossitis or angular stomatitis), and micronutrient deficiencies may not occur in isolation such that physical findings may reflect multiple deficiencies. Nonetheless, physical findings that are correlated with other relevant aspects of assessment provide important data regarding the need for further investigation or treatment.

The following sections describe physical findings in organ systems or disease states. Because physical findings may be nonspecific, associated historical, anthropometric, and functional and biochemical findings are discussed. Table 3.3 summarizes selected physical findings found in nutrient deficiency or excess, some of which are depicted in Figure 3.3.

A The Head and Neck

The temporalis muscles should be visualized for evidence of wasting, a sign of PEM as well as nonnutritional diseases of muscle wasting. Hair may demonstrate alterations in color, texture, and density. PEM may result in hair that is dull or dyspigmented and easily plucked hair. Kwashiorkor may result in the Flag sign, a band of dyspigmented hair surrounded by normally colored hair that indicates a transient period of protein malnutrition, Diffuse alopecia is one of the signs of zinc deficiency, and when accompanied by rash and dysguesia, zinc deficiency should be strongly considered.

Examination of the eyes may reveal several signs of nutrient deficiency. Vitamin A deficiency is associated with reduced night vision (which may require ophthalmologic assessment to confirm) and is later manifest by Bitot's spots visible on the surface of the eye. Thiamin deficiency may result in opthalmoplegia, which classically is lateral gaze palsy.

The mouth is among the common sites that may indicate disorders of nutrition status (Figure 3.3). Cracking or ulceration of the lips (cheilosis), or cracking or ulceration at the corners of the mouth (angular stomatitis), is seen in multiple deficiencies including those of B vitamin, iron, and zinc. Angular stomatitis may also be due to poor fitting dentures, which is associated with reduced food intake.

Glossitis, or inflammation of the tongue, is associated with deficiencies of multiple vitamins, deficiencies of iron and zinc, as well as PEM. Glossitis may result in the tongue appearing swollen or "beefy," and color may be pale, red, or magenta instead of the normal pink color. Loss of papilla may result in the tongue appearing smooth or shiny (atrophic glossitis).

Pale gums may indicate anemia. Bleeding from the gums may indicate coagulopathy resulting from vitamin K deficiency or scurvy.

Cancer chemotherapy may result in pain or ulcers in the mouth and throat (mucositis), a common cause of poor intake in patients undergoing chemotherapy and in some patients undergoing radiation therapy.

Dental health directly impacts dietary intake and eating enjoyment [51,52]. Those who are edentulous or without adequate dentures are at increased risk for inadequate nutrient intake [52]. The presence of caries or periodontal disease is associated with frequent ingestion of fermentable carbohydrate or acid beverage or food.

Goiter as a result of iodine deficiency may be apparent by visualization or palpation of the thyroid. Iodine supplementation has reduced but not eliminated goiter due to iodine deficiency in endemic areas.

B Skin

The skin, like the mouth, is among the more common sites where signs of nutritional problems are observed (Figure 3.3). Tenting of the skin due to dehydration appears as a tentlike fold after pinching the skin. Alterations in skin color include pallor, which suggests anemia, and the orange-yellow hue of carotenemia, also called carotenodermia. Carotenemia is observed with high levels of intake of foods containing carotenoids, with dyslipidemia, or in conditions characterized by diminished conversion of provitamin A carotenoids to vitamin A; these condition include anorexia nervosa, hypothyroidism, liver disease, diabetes, and nephrotic syndrome [53]. Carotenemia may be distinguished from jaundice because the former does not affect the sclerae.

Dermatitis accompanies many micronutrient deficiencies as well as essential fatty acid deficiency (Table 3.3 and Figure 3.4). Classic skin manifestations include the dermatitis of sun-exposed areas in pellagra, perifollicular hyperkeratosis or petechiae of scurvy, and the erythematous perioral and perianal dermatitis of zinc deficiency.

Physical findings of anemia include pallor of the skin and mucous membranes. Populations at increased risk for nutritional anemias resulting from deficiencies of vitamin B_{12}, folate, and iron risk include alcoholics (vitamin B_{12} and folate), the elderly (vitamin B_{12}), women with menometorrhagia (iron), and vegans (iron and vitamin B_{12}). Anemias as a result of PEM and deficiencies of vitamin C, vitamin B_6, riboflavin, and copper may also occur. Copper deficiency may be induced by surgical resection or bypass of the stomach and proximal small intestine or by use of zinc supplements [54,55].

Abnormal bleeding as a result of vitamin K deficiency may be observed if deficiency is severe. Most

TABLE 3.3 Physical Signs of Nutrient Deficiency or Excess

System	Sign	Nutrient or condition
Mouth	Glossitits	Deficiencies of riboflavin, niacin, biotin, vitamin B_6, vitamin B_{12}, folate, iron, zinc
	Angular stomatitis or cheilosis	Deficiencies of riboflavin, niacin, biotin, vitamin B_6, folate, vitamin B_{12}, iron, zinc
	Gingival bleeding	Deficiencies of vitamin C or K
	Dental erosions	Bulimia nervosa
	Dental caries	Carbohydrate or acid intake
	Dental fluorosis	Discoloration or pitting of dental enamel
Eyes	Xeropthalmia	Vitamin A deficiency
	Night blindness	
	Photophobia	
	Bitot's spots	
	Corneal ulceration	
	Diplopia	Vitamin A toxicity
	Nystagmus	Thiamin deficiency
	Lateral gaze deficit	
	Optic nerve atrophy	Vitamin B_{12} deficiency
	Blindness	
	Retinitis pigmentosa	Vitamin E deficiency
	Visual deficits	
	Kayser–Fleischer ring	Copper toxicity
	Sunflower cataract	
	Xanthelasma	Dyslipidemia
Skin	Seborrheic-like dermatitis	Deficiencies of B_6, zinc
	Impaired wound healing	Deficiencies of protein vitamin C, zinc
	Erythematous or scaly rash at sun-exposed areas	Niacin deficiency
	Perifollicular petechiae	Vitamin C deficiency
	Ecchymosis (bruising)	Vitamin K deficiency
	Easy bruising	
	Dry, flaky skin	Zinc or essential fatty acid deficiency
	Depigmentation	Protein-energy malnutrition
	Yellow or orange discoloration	Carotenoid excess
	Pallor	Deficiencies of iron, vitamin B_{12}, folate
Nails	Koilonychia (spoon-shaped nails)	Iron deficiency
	Discolored or thickened nails	Selenium toxicity
Hair	Swan neck deformity	Vitamin C deficiency
	Discoloration, Flag sign	Protein-energy malnutrition
	Dullness	Biotin deficiency

(*Continued*)

TABLE 3.3 (*Continued*)

System	Sign	Nutrient or condition
	Easy pluckability	
	Alopecia	Zinc or biotin deficiency, vitamin A toxicity
Cardiovascular	High-output congestive heart failure	Thiamin deficiency
	Cardiomyopathy and heart failure	Selenium deficiency
Gastrointestinal	Stomatitis	Niacin deficiency
	Esophagitis	
	Proctitis	
	Hepatomegaly	Hepatic steatosis due to diabetes, obesity, Kwashiorkor, choline deficiency, carnitine deficiency
Musculoskeletal	Generalized or proximal weakness	Vitamin D deficiency
	Bone tenderness	
	Fracture	
	Weakness	PEM, hypophosphatemia, hypokalemia, hypomagnasemia, vitamin D deficiency, iron deficiency
	Muscle wasting	Protein-energy malnutrition
	Carpopedal spasm	Hypocalcemia
Neurologic and psychiatric	Peripheral neuropathy or myelopathy	Deficiencies of vitamins B_6, B_{12}, E, thiamin; toxicity of vitamin B_6
	Mental status changes	Deficiencies of thiamin, vitamins B_6, B_{12}, niacin, biotin, hypophosphatemia, hypermagnasemia
	Delirium	Deficiencies of vitamin B_{12}, thiamin, niacin
	Dementia	Deficiencies of vitamin B_{12}, thiamin, niacin

vitamin K-related bleeding is due to warfarin use, which antagonizes vitamin K action. Dietary vitamin K deficiency is observed in alcoholics and those with malabsorptive disorders or poor intake. Vitamin C deficiency may cause gingival bleeding; splinter hemorrhages of the nails; petechial hemorrhages of the skin; and larger bruises apparent on the skin, in muscles, or, in rare cases, internal organs.

Risk for decubitus ulcers and impaired wound healing is increased in deficiency states such as PEM and micronutrient deficiencies but also with obesity.

Skin lesions are not only the result of nutritional deficiencies but also may represent metabolic disorders or sensitivities to components of food. For example, hyperinsulimia may cause acanthosis nigricans, manifest as a gray discoloration around the base of the neck, the axillae, and on extensor surfaces. Dyslipidemia may result in several cutaneous lipid accumulations, such as xanthelasma, which is often found on the eyelid, and xanthoma, which can occur in multiple sites.

C Cardiovascular System

Cardiovascular abnormalities are seldom pathognomonic for specific underlying nutritional issues. Nonetheless, the contribution of nutritional issues to cardiovascular disease should be considered. For example, congestive heart failure (CHF) may be a sign of thiamin deficiency (web beriberi) or Keshan disease due to selenium deficiency in endemic areas. Wet beriberi is characterized by high-output heart failure with rapid heart rate and pulmonary and peripheral edema. Risk for thiamin deficiency may be underappreciated in CHF patients because one investigation found that one-third of patients were deficient [56]. Use of loop diuretics such as furosemide increases thiamin losses, contributing to risk of deficiency in this population [57]. Symptomatic thiamin deficiency has typically been observed in those with alcohol abuse, with very poor intake, or with carbohydrate refeeding. However, it is now recognized that patients who have undergone

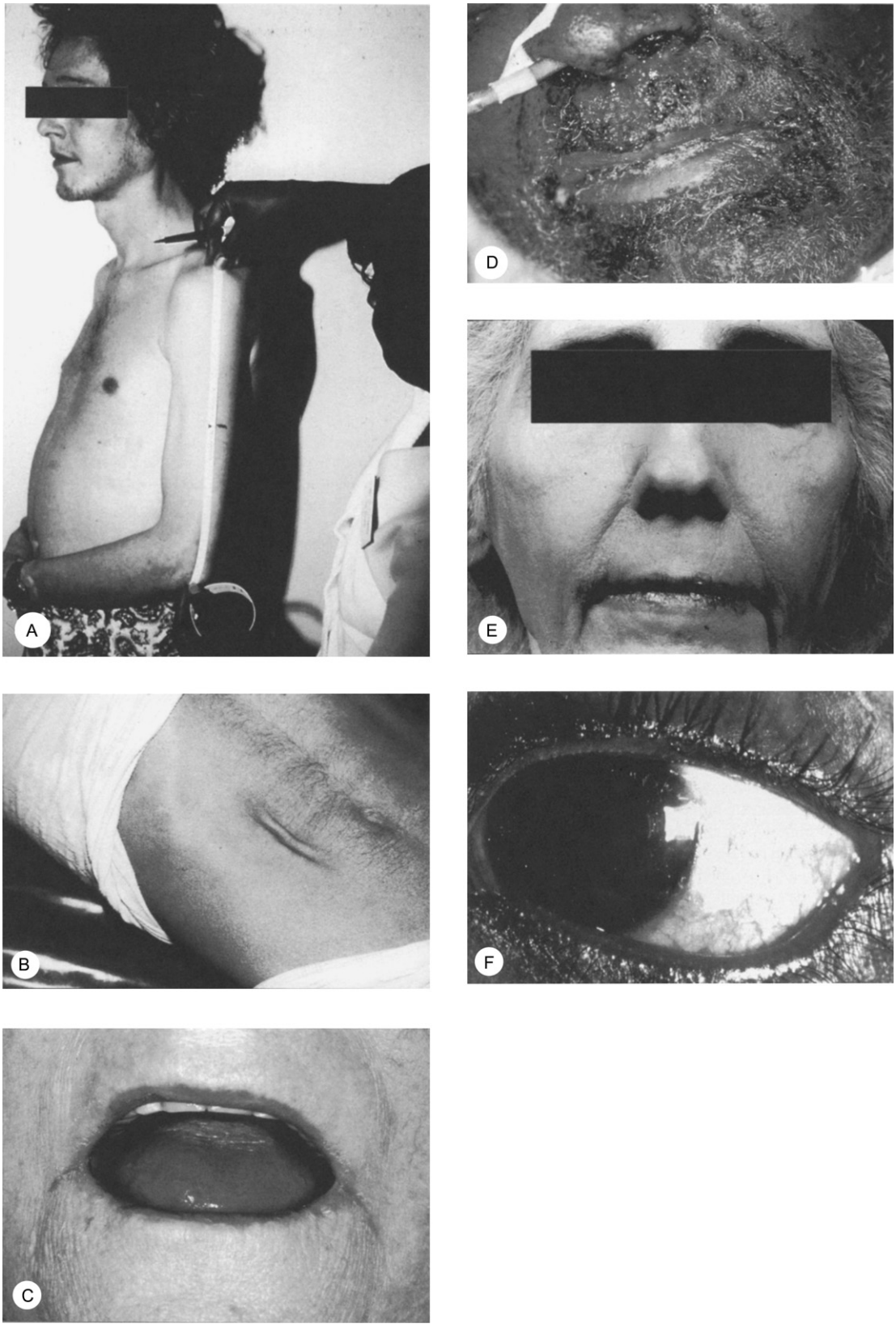

FIGURE 3.4 Physical signs associated with nutrient deficiencies. (A) Muscle wasting in severe PEM. (B) Tenting of skin in dehydration; the skin retains the tented shape after being pinched. (C) Glossitis and angular stomatitis associated with multiple B vitamin deficiencies. (D) Dermatitis associated with zinc deficiency. (E) Cheilosis, or vertical fissuring of the lips, associated with multiple B vitamin deficiencies. (F) Bitot's spot accompanying vitamin A deficiency. *Photos courtesy of Dr. Robert Russell and Dr. Joel Mason.*

bariatric surgery who experience frequent vomiting or poor intake, despite the absence of traditional risk factors, may experience symptomatic thiamin deficiency.

Cardiac cachexia may occur in patients with chronic CHF and is manifest by loss of FFM with variable loss of weight. Fat mass may remain unchanged, may decrease, or may even increase. Cachexia occurs due to inflammatory cytokines and neuroendocrine alterations that result in increased protein catabolism and decreased protein synthesis, increased resting energy expenditure, altered taste, early satiety, and diminished enjoyment of eating [58,59].

D Pulmonary System

Respiratory muscle strength may be diminished in PEM and predisposes to respiratory complications in those with chronic pulmonary disease or in acutely ill patients. Respiratory muscle strength and spirometry have been utilized as components of functional assessment for PEM.

Chronic obstructive pulmonary disease (COPD), like CHF, is associated with PEM due to several mechanisms. Food intake may be diminished by medications, cachexia, or in severe disease may be limited by shortness of breath [58,60]. Chronic treatment of COPD with corticosteroids predisposes to further loss of FFM and gains in FM with central accumulation of fat, loss of appendicular muscle, thin skin with easy bruising, glucose intolerance, and bone loss.

Acute respiratory failure may be precipitated by hypophosphatemia, which may also contribute to failure to wean from mechanical ventilation. Hypophosphatemia may accompany PEM or may occur independently due to alcohol abuse, refeeding syndrome, with correction of diabetic ketoacidosis, and with severe hypovitaminosis D.

E Gastrointestinal System

Diseases of the stomach, small intestine, colon, and liver are commonly associated with PEM and micronutrient disorders. Inflammatory bowel disease, celiac disease, resection of the intestinal tract, and short bowel syndrome may result in dehydration, PEM, and deficiencies of micronutrients and essential fatty acids. The site and extent of disease are important determinants of nutritional risk. Although active gastrointestinal disease may be associated with nutritional risk, patients with inflammatory bowel disease or celiac disease who are asymptomatic may still be at risk. Geerling *et al.* [61] found that patients with Crohn's disease in remission had persistent deficiencies in several water- and fat-soluble vitamins as well as zinc. Patients with celiac disease are at risk for multiple deficiencies, including iron, calcium, zinc, fat-soluble vitamins, folic acid, and vitamin B_{12}. Celiac disease patients may remain at risk for metabolic bone disease even if clinically in remission [62].

Atrophic gastritis, which predisposes to vitamin B_{12} deficiency, increases in prevalence with advancing age. In one survey, more than 12% of a free-living elderly population was found to be deficient in vitamin B_{12} [63]. Drugs that reduce gastric acid secretion may also contribute by a similar mechanism, although this remains controversial. Bariatric surgery that bypasses part of the stomach, such as Roux-en-Y gastric bypass, may also lead to deficiency of vitamin B_{12} as well as deficiency of iron and copper.

End-stage liver disease or cirrhosis is frequently associated with PEM and deficiencies of fat-soluble vitamins due to poor intake, alterations in metabolism, and diminished hepatic storage. Manifestations of deficiency states may be incorrectly attributed to underlying disease, as was observed in some patients with primary sclerosing cholangitis who experienced night blindness, bone pain, or easy bleeding [64].

Chronic pancreatitis or pancreatic insufficiency (e.g., with cystic fibrosis) may lead to maldigestion of macronutrients and fat-soluble vitamins. Postprandial pain in chronic pancreatitis may further inhibit food intake.

F Musculoskeletal System

PEM may result in reductions in muscular size and strength, as well as in functional changes such as reduced work capacity or endurance. Muscle wasting as well as loss of subcutaneous fat may be observed by inspection of the temporalis muscles and the shoulder girdle and by interosseus wasting between the bones of the dorsum of the hand and the muscles of the extremities.

Generalized weakness is a common complaint. It is important to differentiate between the subjective experience of lethargy, which may be described as weakness, and actual diminished strength due to loss of skeletal muscle mass or function. The subjective experience of weakness accompanies dehydration and is an early symptom of PEM and deficiency of multiple vitamins and minerals, the most common of which is iron. Actual weakness may be observed with sarcopenia, PEM, cachexia, and disuse. Hypomagnasemia, hypokalemia, and hypovitaminosis D are among the more common micronutrient etiologies of muscle weakness [65]. Weakness due to neuropathy may also be experienced as muscle weakness.

Malnutrition in children can lead to impaired growth and bony deformities. Children with deficiencies of vitamin D or vitamin C may demonstrate bowing of

long bones of the legs as well as prominence of costochondral joints (the rachitic or scorbutic rosary). Exam findings of osteomalacia in adults are subtler and may include tenderness with palpation of the sternum or long bones. A history of fractures, especially nontraumatic fractures, and bone pain should stimulate consideration of metabolic bone disease as well as calcium and vitamin D status. Persons with diseases known to influence calcium and vitamin D metabolism (e.g., those with malabsorptive disorders, chronic renal failure, and the institutionalized elderly) are at risk for metabolic bone disease, and appropriate monitoring and treatment should be undertaken. Similarly, drug–nutrient interactions that interfere with vitamin D metabolism, such as phenytoin, may increase risk of metabolic bone disease. Hypovitaminosis D and secondary hyperparathyroidism have been reported in patients who have undergone malabsorptive procedures such as gastric bypass or biliopancreatic diversion; hypocalcaemia rarely occurs after gastric bypass but has been observed after the more malabsorptive biliopancreatic diversion [66,67].

G Kidney Disease

Chronic and acute kidney disease and their treatments are associated with a host of nutritional disorders, including protein energy wasting, mineral and bone disorders, and alterations in vitamin status. Nutritional issues vary with the etiology and severity of kidney disease, whether acute or chronic, and if renal replacement therapy has been instituted. Nutrition guidelines for kidney disease are beyond the scope of this chapter but are available elsewhere [68–73].

H Neurological and Psychiatric Systems

Dementia and neurological disorders, such as stroke, Parkinson's disease, and head injury, may impair the ability to recognize, procure, and prepare food and to ingest food. The oropharyngeal phase of swallowing requires voluntary and involuntary neurologic function. A history of difficulty initiating a swallow, choking or gagging, wet cough, multiple swallowing attempts, and retained food in the mouth are signs that should stimulate evaluation for dysphagia.

Signs of bulimia may include dental erosions and parotid hyperplasia because of frequent vomiting. Nutritional problems associated with anorexia nervosa and, to a lesser extent, bulimia include PEM, electrolyte abnormalities, vitamin and mineral deficiencies, and, in the longer term, osteopenia.

Multiple psychiatric or neurological syndromes caused by nutrient deficiency (e.g., thiamin, niacin, vitamin B_6, vitamin B_{12}, vitamin E, and essential fatty acids) or excess because of supplementation or faddism have been described (Table 3.3). In the United States, common predisposing factors to deficiency syndromes are alcoholism, atrophic gastritis, malabsorptive disorders, and gastrointestinal surgery. Of particular importance is that deficiency of vitamin B_{12} may be manifest by neurological or psychiatric symptoms in the absence of anemia or macrocytosis [74]. Vitamin B_{12} deficiency may result in subtle neuropsychiatric symptoms as well as the more dramatic signs of combined systems degeneration and changes in cognition or personality. Thiamin deficiency results in deficits manifest by cognitive changes, cerebellar dysfunction, gaze palsy, sensory and motor manifestations, and eventually dementia.

The current popularity of bariatric surgery has resulted in increased prevalence and awareness of the neurological manifestations of deficiencies of thiamin, vitamin B_{12}, and copper. Kumar has comprehensively reviewed the neurological manifestations of these and other disorders [55].

V FUNCTIONAL ASSESSMENT

Functional assessment is based on the premise that PEM and other forms of malnutrition result in physiologic or functional impairment in measurable processes such as skeletal muscle or pulmonary muscle strength, mobility, and delayed-type hypersensitivity. Functional impairment may contribute to risk for malnutrition due to reduced ability to obtain, prepare, and consume food. Tools developed for functional assessment are used for both nutrition screening and assessment and vary in complexity from questionnaires about function to measurement of handgrip strength and batteries of multistage tasks requiring complex physical and cognitive processes.

A common simple functional test is handgrip strength, which is measured by handgrip dynamometry and correlates with FFM. Reductions in handgrip strength are associated with PEM and generalized muscle weakness [75–77] as well as all-cause mortality [78]. Preoperative handgrip strength has also been found to predict risk of postoperative complications [79]. Handgrip strength is useful in the serial assessment of an individual, but it can also be used for reference to age- and sex-specific norms. In malnourished patients who are provided nutrition support, an initial early increase in handgrip strength may be observed prior to significant accretion of muscle mass; this effect is likely due to repletion of intracellular energy substrates and micronutrients necessary for neuromuscular function [80]. After this initial improvement, more

TABLE 3.4 Components of Selected Multicomponent Assessment Tools

Tool	Population	Health status	Dietary intake or appetite change	Weight or BMI	Weight change	Skinfold or circumference	Physical examination	Functional status
Prognostic Nutritional Index (PNI)	Hospital							
Nutritional Risk Index (NRI)	Elderly	✓	✓		✓			
Prognostic Inflammatory and Nutritional Index (PINI)	Hospital							
Subjective Global Index (SGA)	Hospital	✓	✓		✓		✓	✓
Nutritional Risk Screening (NRS-2002)	Hospital		✓	✓	✓			
Malnutrition Universal Screening (MUST)	Hospital Community	✓	✓	✓				
Malnutrition Screening Tool (MST)	Hospital		✓		✓			
Nutrition Screening Initiative	Elderly	✓	✓	✓				✓
Mini Nutritional Assessment (MNA)	Elderly	✓	✓	✓	✓	✓		✓
Short Nutritional Assessment Questionnaire (SNAQ)	Hospital	✓	✓		✓			

gradual gains in handgrip strength occur with repletion of FFM.

VI MULTICOMPONENT ASSESSMENT TOOLS

Multicomponent tools combine elements of history, anthropometric measurements, physical examination, and biochemical assessments. Combining elements improves sensitivity and specificity in the prediction of nutrition status, need for nutrition intervention, or adverse outcomes such as hospital length of stay or mortality [81]. Depending on the purpose and setting, use of multicomponent tools may be superior to use of single parameters such as BMI, weight loss, or recent intake. Tools have been developed for specific populations, such as children, adults, and older persons, and for settings such as the community, hospitals, or nursing homes. Anthony provides an overview of six nutrition screening tools validated for use in the acute care setting [82]. Some assessment components are influenced by illness as well as by malnutrition. If these tools are used to assess risk for adverse outcomes, however, it may not be necessary to differentiate between these two influences.

Table 3.4 contrasts selected components of some multicomponent assessment tools. In studies in which tools such as those described in Table 3.4 were contrasted, none was consistently superior [83–85]. As suggested by Elia and Stratton, selection of a test should be based not only on the ability of the tool to predict the stated outcome but also on reproducibility, the setting and population, the ease of use, and the time required [81].

VII SUMMARY

Clinical assessment, including physical assessment, is integral to comprehensive nutritional assessment. Elements of physical assessment, such as BMI and weight change, are often central to nutrition screening or assessment. Physical examination findings that are interpreted in the context of other assessment components provide valuable data regarding PEM and micronutrient malnutrition status. Functional assessment and multicomponent assessment tools improve the ability to detect malnutrition, the need for intervention, and predict adverse events.

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